CHEMICAL & METALLURGICAL ENGINEERING

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CO_2 Recorder for Office of Chief Engineer
CO_2 Machine No Moving Parts
ALL TOGETHER NOW!
Owners, Engineers and Firemen can all unite with Uncle Sam to ward off fuel famine with the aid of
Uehling CO_2 Equipment.
Uehling CO_2 Recorder shows the fireman what to do every minute of the shift. It helps him to make good. Uehling CO_2 Recorder furnishes the Engineer at his desk with a perpetual Record of fuel waste.
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As for Uncle Sam, he insists on reliable CO_2 records now from every power plant. UEHLING Records always give the exact facts.
Let us show you why a UEHLING CO_2 Recorder is the simplest way to furnish the Fuel Administration acceptable records and at the same time increase plant efficiency to get a better rating. Write today.
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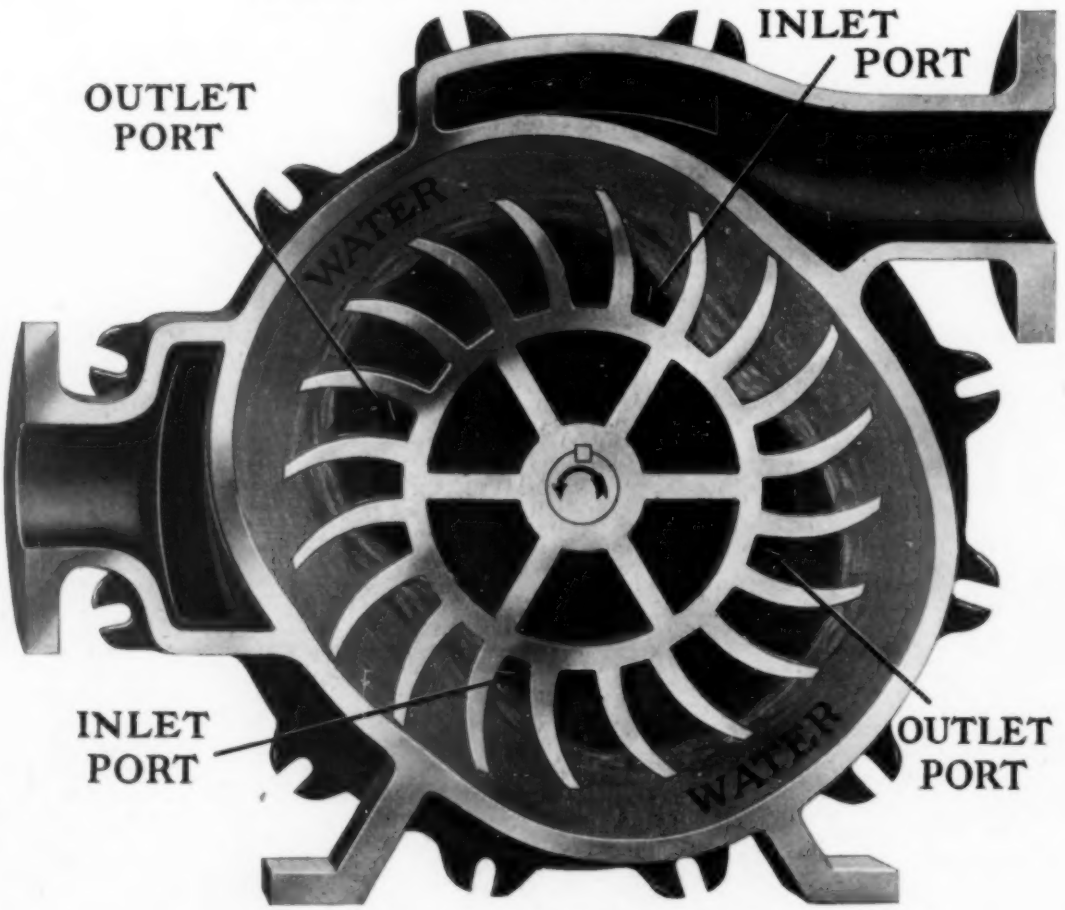
NASH HYDROTURBINE

THE SIMPLEST AIR COMPRESSOR AND VACUUM PUMP



Principle of Operation

The water revolves with the rotor but follows the elliptical casing due to centrifugal force. Twice in a revolution the water alternately recedes from and reënters the rotor.

The Water Acting as a Piston Compresses the Air.

The Hydroturbine contains but one moving part, the rotor, which is cast in one piece, with blades reinforced by shrouds cast integral. The rotor is firmly keyed to a substantial shaft which rotates on heavy annular ball bearings mounted outside of casing. The air is thoroughly washed during compression and contains no oil, as the Hydroturbine requires no interior lubrication. Air is delivered by the Hydroturbine without pulsation.

Various liquids may be utilized as the displacing medium, in connection with the handling of chemical gases.

See these pumps in operation at our exhibit, where Nash Engineers will be pleased to explain their application to your problems.

Booths 244 and 245 Mezzanine Floor

NASH ENGINEERING COMPANY

SO. NORWALK, CONN., U. S. A.

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Increasing Production of American-Made Potash

ACCORDING to the figures given out by the U. S. Geological Survey, the production of potash for the first half of this year was between 20,000 and 25,000 tons of K_2O, and it is estimated that the total for the year will reach 60,000 tons, as compared with 32,575 tons in 1917. This is about 25 per cent of our pre-war importations, and if this country is to become independent of Germany, immediate steps should be taken to further develop our own sources of supply. The cement works and blast furnaces alone should be able to supply our total requirements, but so far these industries have done very little. By the end of 1918 about a dozen cement companies will be recovering potash as a by-product, and incidentally abating the dust nuisance. The blast furnaces are doing practically nothing although it is generally recognized that they would benefit considerably by obtaining cleaner gas for the stoves and gas engines. The manufacturers can hardly be blamed for not putting money in the necessary additions to their plants under the present uncertainty of the whole potash question. Although the present prices are high, no one knows how long they will last, and under the proposed revenue bill most of the profits would be taken by the government as taxes. The manufacturers would not object to this if they were allowed to amortize the cost of plant before being subject to any profits tax. The producers of potash should also be given definite assurance by the government that there will be no "dumping" of German potash after the war.

A source which it seems to us should be thoroughly investigated is the potash-bearing silicate rocks. There are large deposits of these running fairly high in potash, notably the greensands of New Jersey, the leucite deposits of Wyoming, and the sericites and potash-bearing states of Georgia. Although no commercially successful method of extracting potash from silicate in general has as yet been developed, this problem should not be beyond the skill of American chemists and metallurgists. Congress granted an appropriation of $175,000 in 1916 to the Department of Agriculture for an experimental plant for treating kelp, and it seems to us that the silicates offer an even more promising source of potash. We think it would be a very good idea if a similar appropriation were made to the Bureau of Mines for carrying out experiments on these silicates, as if a successful process of extracting the potash can be developed, the supply of raw material is practically unlimited.

Our recent editorial comments on the advisability of

searching iron ores and fluxes are ably supported by the article of Mr. Grasty on "Potash as a By-product," published elsewhere in this issue. The author makes a timely point when he avers that our future production of potash must compete with the German product, and that we must consequently rely on cheap sources of supply. By-product sources usually are inexpensive. The cement industry is already doing something in this line, and the blast-furnace must support in larger measure the production of the cement kiln.

The Evaporation of Weak Liquors.

MANY chemical and metallurgical processes are broken by the cost of evaporating large quantities of weak solutions. Others are more fortunately situated as regards the price of heat or the relative quantity of liquid to be removed. In any case, men who are responsible for the evaporating practice in scores of chemical processes should find much of interest in the article published in this issue on "A Wet Process for Extracting Potash from Cement Dust," in which is described a rather unique condenser-evaporator installation. Briefly, this particular process required the production of a very humid gas, the cooling of this gas approximately to atmospheric temperature, and the collection of its precipitated mist. The practical operation developed a method of conserving furnace energy far beyond the power of the ordinary waste-heat boiler, and apparently applicable to many processes—at least meriting most careful consideration.

Conventional evaporating practice involves the production of large quantities of live steam by the most efficient boiler practice, and the utilization of the latent and sensible heat of the vapor in multiple-effect evaporators. Boiler gases escape at a temperature well above that of the steam produced, and usually carry with them large amounts of heat which go to waste except for the production of draft. Mr. Dean's process takes such gases, reduces them to temperatures but little above the atmosphere, and utilizes the abstracted heat for evaporating purposes. Indeed, it might prove to be more profitable to throw more work on the condenser-evaporator unit, and less on the boiler by eliminating any economizers, which by the way, are often regarded by their possessors as diluted blessings.

Outlook for German Competition in Potash

AT THE potash symposium yesterday Mr. Linn Bradley sounded a note of warning against the danger of national lethargy in recognizing the importance of potash independence. He also pointed out the certainty of German competition after the war and called for national support of the domestic potash industry. His sentiments coincide with those of others who have given the subject consideration, and we are glad to give them publicity in these columns in view of the importance of the matter.

"It seems ridiculous that the United States should be playing the rôle of food granary for ourselves and our allies, also raising the cotton which is so necessary in connection with the war, and yet nothing is being done to provide the potash either for food purposes or for the cotton, except the limited and inadequate efforts due to private initiative. It ought to be emphasized that potash is a subject which should be understood and appreciated by everyone in the nation, and that it should be considered primarily from the national point of view. Does any one of us imagine that there is such ignorance of potash in Germany as exists among our own citizens? No, they have learned that potash is the big German raw-material and economic weapon which they counted upon and are still counting on to help the Kaiser impose his will on you and on me.

"To all those who are assisting in the solution of the problem, I would state that we should soon take steps to solve our post-war problems. The question of the market conditions which will prevail is ever before us. Germany will do all within her power after peace is declared to break down that which will have been built up, the same as she has destroyed the beautiful cities of France. She will endeavor to regain control of the potash situation in this country. Even now she probably has her propaganda all prepared and ready for launching. One need not be surprised to learn that she has agents in the various Governmental departments and bureaus in Washington ever ready to interfere with efforts being made by our technical and business men. Even now we hear rumors to the effect that potash is not a plant food and is not needed for cotton, potatoes and various other crops. Careful investigation of the southern cotton fields should be convincing that this may be another piece of German propaganda. It is difficult to check up these rumors, but all of us should be on guard against them.

"It would be to the national interest in the broadtst way for this country to take steps to forever exclude every ounce of German potash. Tariff, price control and other methods should be earnestly considered. The farmer must be made to realize that he dare not use German potash even if he might obtain it a little bit cheaper than the local product. In other words he must not be a potash slacker. The politician hates to take any action which would have a harmful effect on the farmer vote, so we may look for strong opposition when legislation is urged for protection of the new potash industry. It would be shortsighted if our Congressmen should fail or neglect fully to protect this industry. It should be remembered that Germany will continually strive to break down any barriers which may have been erected, and it therefore behooves us to band ourselves together in an alliance which could fittingly be called the American Potash Alliance and see to it that our interests are at all times being taken care of.

"In unity there is strength, therefore let all parties interested form such an alliance and immediately organize and institute efforts to have the proper legislation passed, and also to conduct a publicity and an educational campaign throughout the country and, generally, to serve the combined interests of those who assist in rendering our country free from the Kaiser as far as potash is concerned. The hearty and active coöperation of the various technical societies should be readily obtained, and I commend these suggestions for the formation of the American Potash Alliance to their attention."

Sidelights on the Exposition

The New Jersey Zinc Co. has a bull's eye on its drawn zinc rods and wire. This is made of very pure metal and, as shown by the exhibit, it machines well and may be turned and used for fittings of various kinds in the place of brass. It may be polished and lacquered, but if this surface will not do, they even show a sample of it that has been gold-plated. Little difficulties should not stand in the way of progress. Another way to avoid the use of brass as displayed by this company is by sherrardizing small iron castings such as are used in building hardware. Another N. J. zinc bull's eye is on zinc oxide, U.S.P., now made in large quantities for the first time in this country.

* * *

Another metal-saving possibility is shown by the National Gum & Mica Co. in a method of coating paper containers with a colloidal solution of tin and afterward burnishing it into a very thin colloidal film. The back of the paper is coated with paraffin to augment its merit, and the front looks like tin. Still another new thing is a high-speed gum whereby long paper cylinders may be turned out by machinery without the usual gooey difficulties, and these are then cut into desired lengths for boxes. And another bull's eye is attached to Mr. Jerome Alexander's new colloidal silver which will doubtless find its main use as a drug, in the treatment of diseases of the mucous membranes. For certain of these, silver in a very finely divided state seems to be a specific. If applied in the form of silver nitrate or in its presence, an artificial membrane or coagulum is produced over the places where the micro-organisms have bored themselves in and where they proceed unharmed in their nefarious business. It appears that this defect has been overcome in Mr. Alexander's invention.

* * *

The grape-juice girls are on hand again, all over the Palace, selling the beverage at ten cents *per*, in sterilized paper cups. It is excellent grape juice, and we observed but two criticisms upon it among all the thousands present. One was from a stout, red-faced man who declared, as he stood drinking it, that it had an "unfinished" taste. If it had been finished as he desired it we are convinced that the internal revenue officers would soon have been worrying the girl that sold it. The other criticism was by example rather than by precept: across the way from the stand is the booth of the Celite Products Co. where samples are shown in pairs, to exhibit various products before and after filtering through their filters. These include lemon oil, soap, lye, kola tonic, molasses, apple cider, caster oil AND grape juice among many other things. The clear, ruby, filtered grape juice serves well the purposes of the exhibitors, but we have no faith in its appeal to the stout man with the red face. No amount of filtering would give it the "finish" that he desired.

* * *

The American masks have the merit of being effective against lethal gas even when the face-piece is torn or cut, although in this event of course the soldier would not be immune against torture gases.

A Freudian philosopher was observed contemplating the U. S. Army mask for horses. "Here we see," he exclaimed, "the evidence of a wish on the part of the designer which is apparent to every true Freudian. He wanted to be in the woods, hunting big game, instead of doing the work in hand, because he has unconsciously made the horse to resemble a moose!" There certainly is nothing like Freudian philosophy for boring into the other fellow's soul!

* * *

The chemical-warfare exhibit is distributing "literature," which means copies of rules and general orders relating to chemists and engineers in essential industries. It will surely be a great convenience to manufacturers who are so engaged because here they may obtain concrete information. The orders are very direct and simple; they are written to be understood and obeyed, and not quibbled over. There are rules for the allocation of enlisted men to industry, which means getting men out of the ranks and back into the works. It can be done but it isn't easy and it doesn't look profitable to undertake unless the industry is "essential to the prosecution of the war," and the man's work cannot be done by any other man or woman. It doesn't seem so many years ago when the most dreadful thing that could happen was the loss of money to a corporation. The War Department does not seem to consider it in this light. What mustn't happen is keeping men out of the army without good and sufficient reasons.

Many men are needed in industry far more than they are needed in the ranks, and yet they feel ashamed not to be in the army. They want to feel that they are in the fight and in it with a gun. Sometimes an impelling reason for their unrest has been that when they returned home and went to work again in the factory they were called slackers. Instructions, therefore, have been issued for men on indefinite furlough, when such furlough is granted for periods to exceed three months, that the regulations as to uniform shall be the same for them as for honorably discharged enlisted men. They are authorized but not required to wear the service uniform, but it shall be furnished and maintained without expense to the United States. They must not wear it, however, while performing manual labor.

This rule sounds pretty good to us. If men are teased for not being on the firing line they can put on their uniforms and stand forth in them in all the dignity of a soldier of the United States.

* * *

Of course, everybody knows how to run a bank, a railroad or a newspaper. This is confirmed by the frequent criticisms of banks, railroads and newspapers that we hear on all sides from nearly everybody, with specific details as to what should be done that it left undone and wherein capital errors lie. And yet, there are little details in banking that require study and experience—just as we find this need in chemistry. So the Irving National Bank of New York has taken a booth at the Exposition and Mr. Dimse, their representative, says that it bids fair to be abundantly worth while. The inquiries in regard to banking facilities, more particularly as to export trade, are frequent and sincere, and opportunities to get posted in regard to acceptances, foreign exchange and a considerable series of other subjects are provided for by numerous pamphlets issued by the bank.

From A to Z With the Exhibitors

AIR REDUCTION CO. An exhibit of compressed oxygen, acetylene, nitrogen, hydrogen, gas welding supplies, ammonia, cyanides, formates, ferro-cyanides, Paris blue and Turnbull's blue. In charge of exhibit: R. T. PEABODY, MISS L. E. MARRS.

ALBERENE STONE CO. Complete chemical laboratory hood, the superstructure of hood being Alberene stone; table top, reagent shelves and sink. In charge of exhibit: A. Y. MEEKER, W. K. FIELDS, N. N. MONEYPENNY, R. J. NYCE.

AMERICAN PIPE BENDING MACHINE CO. A Model S Junior and a Model A standard "Wonder" pipe bending machine. In charge of exhibit: E. P. BLAKE.

ANACONDA COPPER MINING CO. An exhibit of copper bars, cathod, anode billets, sulphate and blister copper together with selenium, tellurium, nickel sulphate, zinc and silver. In charge of exhibit: S. SKOWRONSKI.

H. REEVE ANGEL & CO., INC. Whatman analytical and American industrial filter papers; Labruco rubber tubing. In charge of exhibit: ERNEST CHILD.

ANTI-HYDRO WATERPROOFING CO. A non-corrosive concrete waterproofing. In charge of exhibit: M. D. HAUSLING.

BACHMEIER & CO. Dyestuffs as follows: Congo red, analine black, patent blue; Baco direct rose and pink, which is fast to acid; acid fast red, direct yellow, methyl violet, direct blue, sulphur black, sulphur khaki and chrysophenine. In charge of exhibit: E. J. STRUCK, MARSDEN LORD.

J. T. BAKER CHEMICAL CO. Laboratory analysed chemicals, organic acids, barium, copper, cobalt, ferric lead, magnesium, manganese, nickel, potassium, sodium salts, etc.

THE BARBER ASPHALT CO. Samples of Genasco roofing, shingles, mastics, waterproofing, paints and varnishes, Genasco asphalt putty, Genasco mineral rubber, Trinidad and Bermudez Lake asphalts, Gilsonite, acid-proof mastic tank linings. In charge of exhibit: E. J. CARLEN, A. S. LEWIS, THEODORE THOMAS.

THE BARRETT CO. An exhibit of the Chemical Department which includes coal tar products, toluol, ammonia, paracumaron resins, phenol, benzol, cresols, pyridin, naphthalin, resorcin, B.R.C. rubber filler. In charge of exhibit: H. G. SIDEBOTTOM.

BOYER OIL MFG. CO. An exhibit of oils, including cottonseed, castor, soya bean, peanut, sesame, cocoanut, rape seed, palm kernel, china wood, palm, popy seed and all oil cakes. In charge of exhibit: W. G. REED.

BROWN INSTRUMENT CO. Thermometers and recording gages. They will exhibit specially encased instruments which are protected from fumes, dirt, etc. In charge of exhibit: GEORGE W. KELLER.

BUFFALO FOUNDRY AND MACHINE CO. An extensive exhibit showing expansion tanks, evaporators, nitrators, vacuum dryers, vacuum pumps; high concentrator, vertical tube evaporators; horizontal tube evaporators and rapid circulation evaporators. In charge of exhibit: E. G. RIPPEL.

CANADIAN ELECTRODE CO. Carbon electrodes.

CANADIAN ELECTRO PRODUCTS CO. Acetic acid, acetaldehyde, paraldehide, acetone, todium acetate, mercuric oxide.

CELITE PRODUCTS CO. Filter-cel, sil-o-cel, high-temperature insulation, and celite, also samples of clarified oils. In charge of exhibit: W. S. COLLINS.

CHEMICAL PUMP AND VALVE CO. Lead and stoneware pumps. In charge of exhibit: F. A. WARTER.

CONSOLIDATED COLOR & CHEM. CO. Gallocyanine (fast navy blue), sulphur dyes, chrome dyes. In charge of exhibit: H. A. METZ.

CONTACT PROCESS CO. Sulphuric acid, 50 deg., 60 deg. and 66 deg.; oleum, 20 per cent; nitric acid, muriatic acid, salt cake and niter cake.

CORNING GLASS WORKS. Laboratory glassware, Pyrex and colored signal light glassware. In charge of exhibit: G. W. DRAKE.

CRANDALL PETTEE CO. Gas and electric automatic baking and drying ovens. In charge of exhibit: PAUL DELANY.

CRESCENT INK & COLOR CO., INC. An exhibition showing how ink is made. In charge of exhibit: N. A. MCMANUS, JOSEPH M. PETRY, WALTER A. CONLAN.

DOW CHEMICAL CO.: Samples of chemical products manufactured by the company. Since entering the war this company has developed and perfected on a large scale the process of synthetic indigo 20 per cent. paste and dibrom-indigo 20 per cent. paste. The product is pronounced equal in every way to that imported from Germany before the war. Diethylaniline is also being manufactured on a commercial basis.

DUPONT & CO.—The space occupied by the duPont Company is the largest ever occupied at the Chemical Exposition. The exhibit shows most of the 300 products made by the company. For the first time there is displayed a rather complete lot of dyes which have been manufactured during the past year. The Arlington Works division exhibits a line of high-class toilet articles made from ivory pyralin. In charge of exhibit: R. L. VILAS, STANLEY F. WHITE, J. A. GWYN.

DURIRON CASTINGS COMPANY.—A line of pumps, cocks, valves, pipe, kettles, exhaust fans, nitric acid condensers, bleacher pots, denitrating towers and Hough sulphuric acid concentrators. The latter has been on the market since the United States entered the war. It is built along entirely new lines and is applicable to most processes where evaporation is required. In charge of exhibit: J. R. PITMAN.

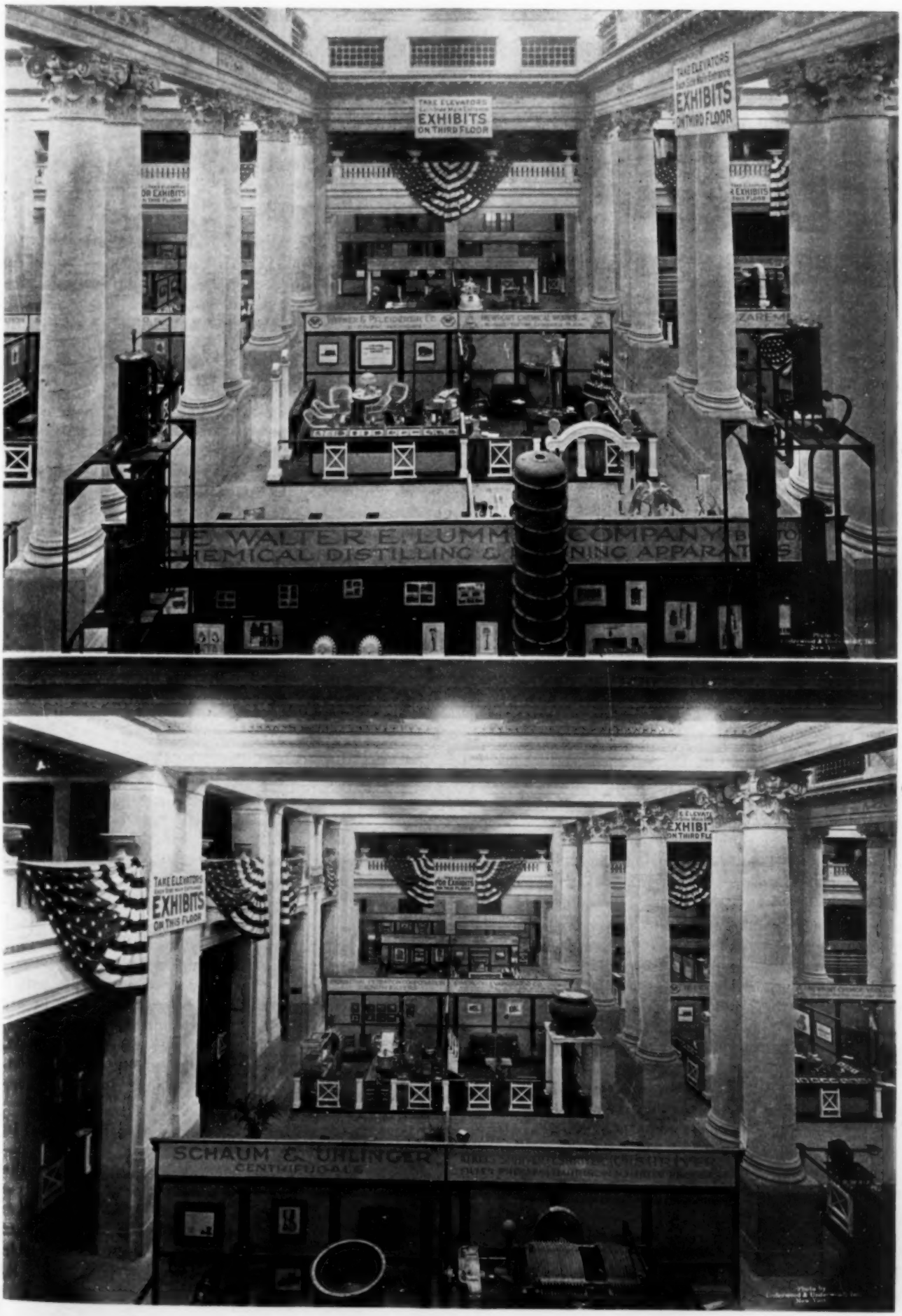
EDISON INTERNATIONAL CORPORATION. Coal-tar products; chemicals; drugs. Paraphenylenediamine is featured in the exhibit. In charge of exhibit: T. C. LEMLEY, J. D. LYMAN, W. C. WETMORE, E. P. MOUSIR.

THE ELECTRIC FURNACE CO.: Exhibition of photographs and drawings of furnaces that are producing war materials, such as airplane parts, billets for shells, melting furnaces for airplane and submarine castings. In charge of exhibit: D. D. MILLER.

ELECTRO BLEACHING GAS CO.: Manufacturers of liquid chlorine. In charge of exhibit: J. A. KIENLE, D. K. BARTLETT.

ELECTROLYTIC ENGINEERING CORP.—The Wheeler process for the manufacture of caustic soda and liquid chlorine will be exhibited by means of photographs and cross-sectional views to show the details of the cell and process. In charge of exhibit: R. G. KEHOE.

ELECTROLYTIC ZINC COMPANY. An exhibit of zinc


TAKE ELEVATORS
EXHIBITS
ON THIRD FLOOR
TAKE ELEVATORS
EXHIBITS
ON THIRD FLOOR
SCHAUM & UHLINGER
CENTRIFUGALS

products. In charge of exhibit: S. G. SCHATZBERG, A. W. HAHN, W. H. NAUGLES.

ELECTRON CHEMICAL CO.—A complete cell for the electrolytic production of chlorine and caustic soda, together with photographs illustrating some installations. In charge of exhibit: HERBERT I. ALLEN.

G. H. ELMORE.—Acid-proof centrifugal pumps, with blueprints showing interior arrangement. Blueprints of centrifugal driers. BLAIR CAMPBELL & MCLEAN, LTD., from Glasgow, Scotland, are associated with Mr. Elmore in this exhibit, but on account of the scarcity of cargo space it has been impossible to secure specimens of their chemical apparatus for exhibition purposes. In charge of exhibit: G. H. ELMORE, R. W. RIGLER, A. C. WOOD, For BLAIR, CAMPBELL & MCLEAN, LTD., JAMES C. LAWRENCE.

ELYRIA ENAMELED PRODUCTS CO.—Elyria cast iron glass-enameled equipment, including a 125-gallon still, 125-gallon open jacketed kettle, 35-gallon kettles, 2-gallon stills and autoclaves. Practically all of the cast iron apparatus has been developed since the beginning of the war, due to the great demand occasioned for such apparatus formerly furnished by foreign makers. In charge of exhibit: WM. E. GRAY.

EMPIRE CHEMICAL CO.—This exhibit consists mainly of saccharine. In charge of exhibit: S. J. NATHAN.

EMPIRE LABORATORY SUPPLY CO.: Glass apparatus manufactured at Vineland, N. J. This company is making glass apparatus which formerly came from Germany. In charge of exhibit: PHILIP FREEDMAN, M. A. GOLDSTEIN.

EVERLASTING VALVE CO.—"Everlasting" valves in all sizes from 16 in. to ¼ in., arranged in pyramid about 40 in. diameter at the base and extending 13 or 14 ft. from the floor. Everlasting tandem valves. In charge of exhibit: EDWARD N. CORNING.

W. L. FLEISCHER & CO., INC.—Small-scale model of a warm moist air dryer, built especially for the drying of chemicals, fruits and vegetables. This will be an exact model, complete in every detail. It has been developed entirely since our country entered the war. In charge of exhibit: R. E. KEYES, A. W. LISSAUER.

FOOTE MINERAL CO.: Various mineral products and their derivatives as well as ores and compounds of the rarer elements including zirkite, antimony trisulphide, manganese dioxide, zirkite bricks, cerium-iron alloy, ammonium molybdate and molybdic acid, strontium sulphate, titanellow colors and zirkonalba. A feature of the exhibit is the projection of bright line and absorption spectra of the rare element salts, as well as processes of crystallization. In charge of exhibit: H. C. MEYER.

FOXBORO CO., INC. A temperature controller, CO_2 recorded and recording pyrometer all in operation; recording hydrometers, planimeters, time recorders, gage boards with instruments, CO_2 recorders, indicating and recording thermometers; gages, pressure, syphon, mercury, vacuum and liquid level; pyrometers; revolution counters. In charge of exhibit: W. W. PATRICK, M. B. HALL, L. H. DUPAUL.

FULLER-LEHIGH COMPANY. A model of the Fuller-Lehigh pulverizer mill, with samples of chilled charcoal iron castings for abrasive resistance. In charge of exhibit: C. R. RINEHART, E. H. FROMM, W. A. STUBBLEBINE, G. D. MEASE, P. F. STUFFER.

CHAS. F. GARRIGUES CO.: A display of chemicals and special exhibits of caustic potash, stearate of zinc and sulphur dioxide. In charge of exhibit: OTTO F. ANDERSON and other representatives.

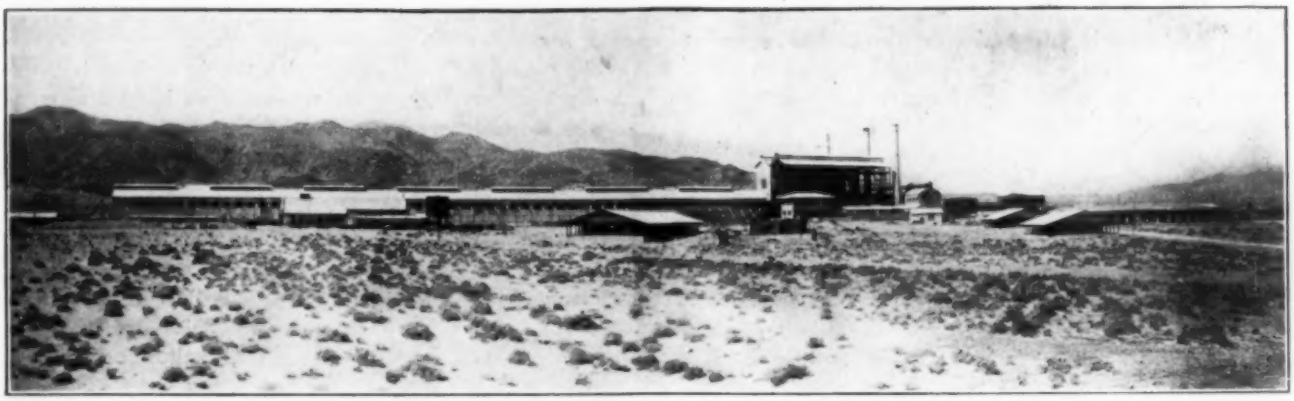
GENERAL BAKELITE CO.—Bakelite raw materials and finished products made from same. The raw materials include moulding material, lacquer, varnish, cement and enamel. The finished products show a wide range of mechanical and electrical articles made from various bakelite moulding materials. The application of lacquer, protective enamel and cement is also shown. Bakelite rods, sheets and tubes manufactured from bakelite canvas and paper is featured in the exhibit. Numerous other articles are shown which have become more or less well-known to the general public, such as pipe-stems, umbrella handles, fountain pens, etc. In charge of exhibit: HYLTON SWAN.

GENERAL CERAMICS COMPANY—Armored stoneware centrifugal pumps, armored stoneware exhauster, machine for etching copper plates by nitric acid, stoneware automatic acid elevator. In addition to the foregoing which will be shown in operation, there will be a model of the Valentiner nitric acid installation which has been adopted by many of the belligerent countries, as well as many of the large industrial concerns here and in Europe. All of this material has been developed in this country since the war for the first time. In the exhibit will be one of the largest stoneware vessels ever manufactured in this country, although not the largest manufactured by this company. There will also be miscellaneous stoneware equipment, a new tower filling, and a variety of small shapes for high-temperature work. In charge of exhibit: PERCY C. KINGSBURY, F. A. WHITAKER, K. J. PETERS.

GENERAL CHEMICAL COMPANY—Commercial and C. B. acids and ammonia, reagents, acetyl chloride, copper sulphate, iron salt, lead acetate, magnesium sodium and tin salt, zinc sulphate, "Orchard" brand of insecticides and fungicides, and "Lariat" brand cattle dips, and "Ryzon" baking powder. In charge of exhibit: N. PETERKIN and members of sales staff.

GENERAL ELECTRIC COMPANY—Flow meters for measuring steam, water, air, oil and gas. A long list of processes and commodities relating to the chemical industry, developed in the company's research laboratory. The diversity of the activities of the laboratory is indicated in the variety of the exhibit, which covers improved lighting, radio apparatus, searchlights, X-ray apparatus, Coolidge tubes, water japans, metals, alloys, chemical compounds and smoke precipitation. In charge of exhibit: L. W. SHUGG and other representatives of the company.

GENERAL FILTRATION COMPANY—Filtros plates in various sizes, grades and shapes, being uniformly porous and acidproof, are finding extensive use in the chemical industry. The porosity of the material will be demonstrated by forcing air through a plate which has been saturated with water. Electro-filtros, a porous acidproof diaphragm, will be exhibited in electrolytic cells of various sizes. In charge of exhibit: F. E. LEIBY.



Potash from Searles Lake*

An Account of the Development of a Project for the Recovery of Potash from the Saline Water of a California Lake—The Product Contains Sixty-Five Per Cent Potassium Chloride

BY ALFRED DE ROPP, JR.
Research Engineer American Trona Corporation

FOR the following topographical description of the Searles Lake Basin and its porous salt bed, I am indebted to *Bulletin* 580-L, written by Hoyt S. Gale of the United States Geological Survey.

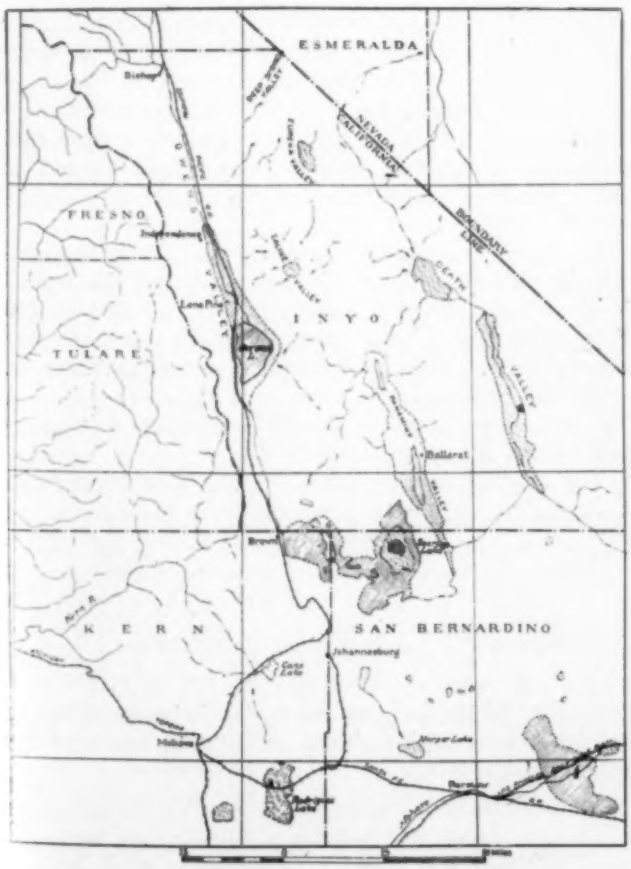


FIG. 1.—MAP OF THE CALIFORNIA SALINE LAKES

His description of Searles Lake and the surrounding country is the clearest and most comprehensive of any that have come to our notice. Fig. 1 shows the location of California saline lakes, and Fig. 2 their respective elevations.

Searles Lake Basin is a broad, roughly circular valley or depression eight to ten miles from east to west and twenty to twenty-five miles from north to south, bordered by the abruptly rising slope of the surrounding ranges. This basin lies between the Argus Range on the west and northwest, and the Slate Range on the east; the latter a narrow, rocky wall, which divides it from the larger and deeper depression of the Panamint Valley.

The Searles Lake Basin was, during a part of the glacial epoch, occupied by at least one deep lake, whose traces are still so distinct as to be indisputable.

While the waters stood at their highest position the Searles Basin was flooded to a depth of 635 to 640

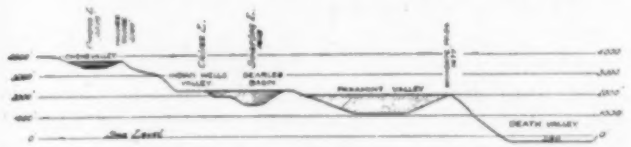


FIG. 2.—PROFILE SURVEY CROSSING LAKES

feet above the level of the present valley bottom, and the lake extended back through the Salt Wells Valley to join with a broad, shallow lake that flooded the greater part of the Indian Wells Valley.

With the lowering of the water-level less than seventy-five feet, the divide in the volcanic peaks between Indian Wells Valley and Salt Wells Valley became an actual division between two distinct water bodies, and for a time here also there was a period of overflow from Indian Wells Valley to the lower waters in the Searles Basin, in the same way that Owens Valley overflowed and spilled its waters into Indian Wells Lake. These are facts attested to by the records of the ancient shore lines and water channels.

The determined elevation of the lowest part of the present salt flat in the main Searles Basin is 1,617.6 feet above sea level.

*A Paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 25, 1918.

The Owens Lake, during a period of former greater water supply, overflowed the divide at the south end of its basin and its surplus waters flooded in turn a succession of lower basins, of which the Searles Basin was one of the largest.

The Owens waters, after passing the Haiwee Divide, dropped some fifteen hundred feet in about thirty miles to Indian Wells Valley, and then spread out in a broad and relatively shallow sheet of water. This, in turn, also overflowed, its waters passing by way of Salt Wells Valley and a rock cut gorge at the lower end of that valley into the Searles Basin.

Eventually, the waters rose in the Searles Basin to such a height that all three of these valleys were submerged in one continuous body of water. The maximum water level in this basin was clearly determined by the elevation of an outlet pass on the south side of the basin, whence its surplus waters flowed into the extreme south end of Panamint Valley.

In the Panamint Basin a history similar in some respects to that of the Searles Basin was repeated. The waters rose until the height of the lowest outlet was reached, and as they evidently remained staionary at about that level for a relatively long period, it is presumed that this level was determined by the overflow of its surplus waters.

Salt Deposit Prospected by Drilling

The most distinctive feature of this desert basin is the immense sheet of solid white salts that lie exposed on its bottom. It is to this salt deposit that the name Searles Lake has been generally applied. So far as known, at present the deposit is unique in this country in the variety of its saline minerals.

Fig. 3 shows two cross sections of the crsytal body. These were plotted from data obtained from the numerous wells which were drilled by the California Trona Company to comply with the assessment work necessary to hold its claims. Some 300 wells were thus drilled.

As may be seen, the crystal body underlies the surrounding mud flats found along the shores of Searles Lake.

The area of salt crust in the Searles Basin is some twelve square miles in extent, and averages from 65 to 75 feet in depth. The formation of the crystal body is such that the brine with which it is associated is absolutely free-flowing, and nowhere, even by extended pumping operations, have we been able to lower the level of the brine in the lake at any one spot to a noticeable extent.

The main or central salt deposit is a firm but extremely porous bed of salt crystals, so hard and compact that roads are built on it, teams and motor trucks have no difficulty in driving over its surface, and even the concrete foundations of the American Trona Corporation's pump house were laid on the surface of the crystal body.

The first fifteen to twenty feet of the crystal body is composed of cubical halite and will analyze 90 per cent (or better) NaCl on a dry basis. Below this are alternating and irregular layers of salts, respectively high in trona, a sesquicarbonate of soda, sodium chloride, and sodium sulphate. The potash content of these layers is very irregular, layers of potash bearing crystals having been discovered by various drilling operations, which ran from fourteen to thirty-odd per cent potassium chloride. (The average potash content of the crystal body is roughly 4 per cent potassium chloride.)

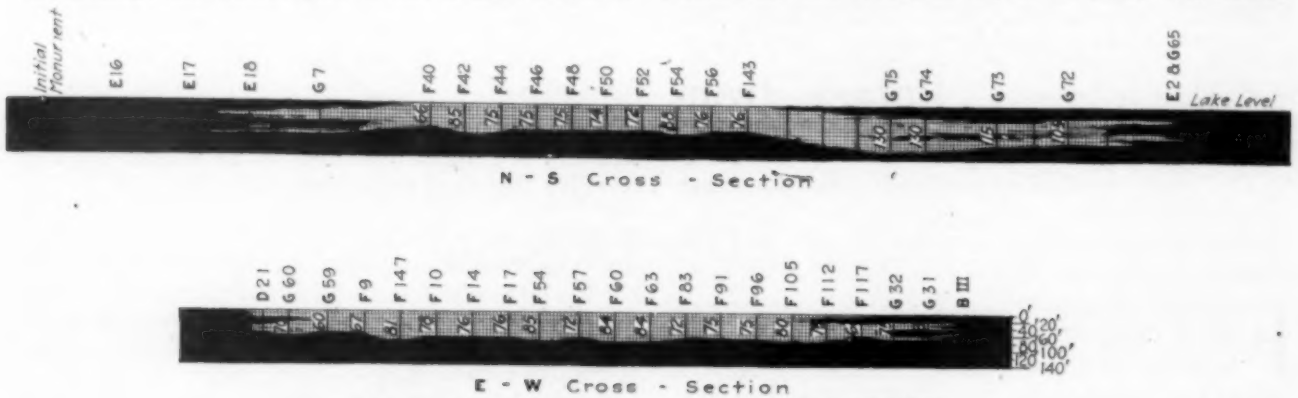


FIG. 3.—CROSS-SECTIONS OF SEARLES SALT DEPOSIT

In a report made to the American Trona Corporation by Charles S. Lee it is estimated that the crystal body contains 110,000 million gallons, or 594,000,000 tons of brine. This does not include any incoming waters from either underground or surface sources. This brine will average 4 per cent potassium chloride. The potash contained in this brine amounts to 23,760,000 tons of potassium chloride.

The average brine pumped by the American Trona Corporation has the composition given in Table I.

TABLE I—AVERAGE COMPOSITION OF BRINE

	Per Cent
Na	11.00
K	2.50
Cl	12.50
CO_2	2.65
SO_4	4.65
B	.35

In view of the process in use, the brine is given the arbitrary composition shown in Table II based on the values in Table I.

TABLE II—COMPOSITION OF BRINE BASED ON VALUES IN TABLE I

	Per Cent
NaCl	16.50
Na_2SO_4	6.90
Na_2CO_3	4.70
$Na_2B_4O_7$	1.50
KCl	4.75
Specific Gravity	1.290 at 30 deg. C.

All the CO_2 is figured as normal carbonate, although the brine contains some bicarbonate. This brine is pumped to the plant from wells drilled in the crystal

body of Searles Lake. The brine is pumped to storage tanks and from them directly to the evaporators. It passes first through a 16-foot Manistee vacuum pan, which is used merely as a pre-heater. From this it is pumped to three 22-foot pans of the same type, which are operated in triple effect.

The pans handle from 200,000 to 250,000 gallons of raw brine and about 100,000 gallons of mother liquor

FIG. 4.—PUMP HOUSE BUILT ON SALT DEPOSIT

per twenty-four hours. This total of 300,000 to 350,000 gallons of liquor is concentrated to about 100,000 gallons of "concentrated liquor" before being sent to the crystallizing house to cool.

During the boiling, sodium chloride, sodium sulphate and sodium carbonate are salted out. These tailing salts drop to the bottom of the vacuum pans and are removed by salt elevators of the regular Manistee type. The elevators discharge their salts into waste salt cones from which they are washed away by water.

Machinery is being installed by Dr. H. W. Morse, technical manager for the corporation, by which we will recover 95 per cent of the potash formerly carried away by these waste salts. This will increase our output by some ten tons (or better) of potassium chloride per unit per twenty-four hours. Operating under the old system this was previously lost to us.

Evaporation and Crystallization

The liquor in the pans is boiled down to the point where potassium chloride begins to salt out, and is then sent to crystallizing vats in this condition at a temperature of 90 to 95 deg. C.

The temperatures and vacua are about as follows:

Pan No.	Vacuum, In.	Temp., Deg. C.
4	24.5	50-55
3	24.5	50-55
2	21.0	70-75
1	12.5	90-95

The triple-effect pans are operated with constant flow, liquor entering the pan next the vacuum pump (where the vacuum is highest and the boiling point lowest) and passing in a constant flow from this pan through the intermediate pan to the final high-temperature, low-vacuum pan, and from this pan to the crystallizing vats.

Cooling and crystallization take place in crystallizing vats 54 by 15 by 6 feet. There are 36 such vats in the unit now operating, and the day's run of hot concentrated liquor fills from three to four of these. The vats cool for about eight days, and the liquor, now nearly at atmospheric temperature, is then drained off.

The crystal crop is shoveled into a traveling box and is carried to a drain floor, where it is allowed to lie for about a week or so before shipment.

Composition of Raw Material and Products

Table III gives the average composition of raw brine,

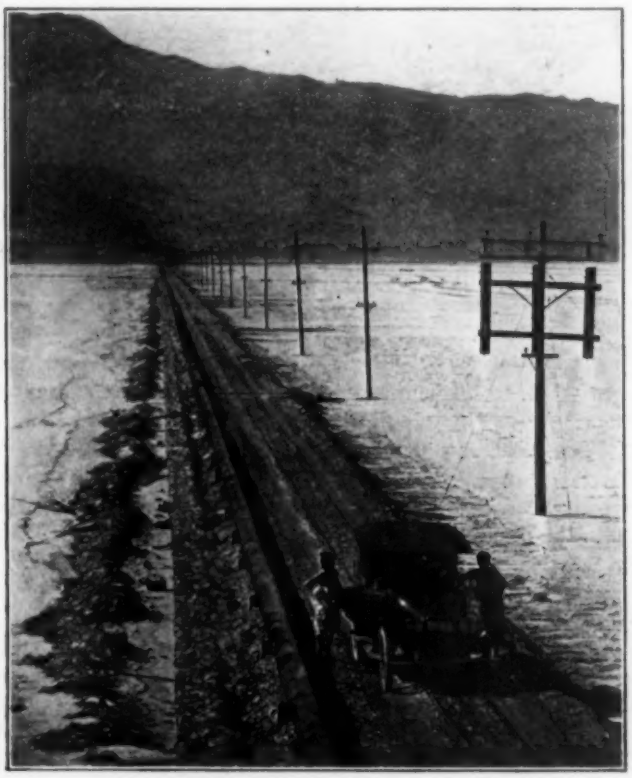


FIG. 5.—ROAD CROSSING SALT DEPOSIT

concentrated liquor, mother liquor returned to the system, and crude potash salts ready for shipment:

TABLE III—PERCENTAGE COMPOSITION OF RAW MATERIAL AND PRODUCTS

	Raw Brine	Concentrated Liquor	Mother Liquor	Crude Potash Salts
$Na_2B_4O_7$	1.50	8.81	7.82	10.91
Na_2CO_3	4.70	10.82	10.53	1.70
NaCl	16.50	9.67	9.43	10.93
Na_2SO_4	6.90	2.58	2.08	0.44
KCl	4.75	14.87	10.82	66.34
H_2O	.....	.....	.....	9.66
Total	34.35	46.75	40.68	99.98
Sp. Gr. at	1.290	1.384	1.362	.....
Temperature, Deg. C.	30	38	34	.....

The American Trona Corporation is producing to date some 1800 tons of crude potash salts a month. Additional equipment, such as a nearly completed second unit, together with a 300-ton ice plant for refrigerating purposes and new methods for treating the concentrated liquor (devised under the direction of Dr. H. W. Morse) will enable the American Trona Corporation to produce by the end of October some 4500 tons

of potash salts a month, analyzing from 75 to 80 per cent potassium chloride and containing less than 3.5 per cent borax, figured as anhydrous sodium tetraborate.

By the first of 1919 the American Trona Corporation will be producing some 40 to 50 tons of refined borax daily analyzing 99.50 per cent $Na_2B_4O_7 10H_2O$.

Pump House, Transformer Station and Manifolds

The pumping equipment consists of two all-iron centrifugal pumps each capable of delivering 750,000 gallons of brine per twenty-four hours to the company's storage tanks. The pumps are connected by short manifolds to six wells drilled through the crystal body.

The pump house and a raised road on which is operated a narrow-gage, gasoline locomotive and dump cars, are built directly on the surface of the crystal body, as shown in Figs. 4 and 5. Our assay map of the crystal body has shown us that this is the most favorable location for our pumping plant.

The road built out to the pump house is about three and one-half miles long. Between 19,000 and 20,000 feet of ten-inch iron pipe connects the pumps with two storage tanks of 500,000 gallons capacity each. The pipe line is laid on concrete piers. It is insulated against changes in temperature by a two-inch layer of hair felt and a one-inch layer of wool felt, the insulation being protected against the elements by a thin sheet of black iron, which is fastened by narrow iron straps.

In Fig. 6 is shown a general view of the plant. At the left are the storage tanks. Next is the boiler plant containing 12,500 hp. Babcock & Wilcox boilers, which supply steam for operating the steam turbines; high-pressure water pumps for the Pelton water wheel drives on the pumps; elevators and propeller shafts of the evaporators, and the Corliss engines which drive the ammonia compressors in the new refrigerating unit. The exhaust steam from these turbines and steam engines is fed to the evaporators.

The Pelton water-wheel drives having proved costly and inefficient to operate, the new management is replacing them with electric drives, thus effecting a considerable saving in oil.

Between the boiler houses and evaporator buildings rise concrete chimneys, 15 ft. high and 9 feet in diameter in the clear on top. The two evaporator buildings will house, when completed, two triple-effect 22-foot diameter Manistee vacuum pans, and two double-effect 16-foot diameter pans of the same design. To the right may be seen the crystallizing house, 180 feet wide and 800 feet long.

The equipment in the refrigerating unit which is under construction consists of three 100-ton De La Vergne ice machines, driven by three Corliss engines of 300 hp. each.

Trona Reef, Northeast End of Searles Lake

The company owns some seven hundred acres of claims here. The high grade trona in these claims amounts roughly to 40,000 tons. Besides this there are some 20,000 tons of a lower grade trona comprised in these claims.

The American Trona Corporation has built a raised road completely across the lake, connecting the Trona Railroad with its Trona claims by a narrow gage, gasoline operated railroad.

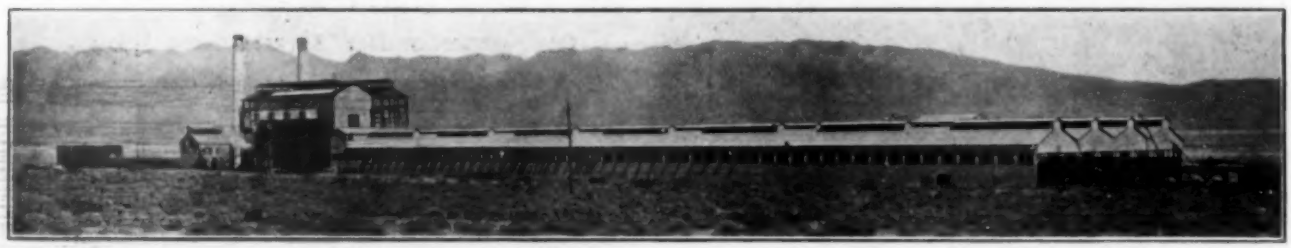


FIG. 6.—GENERAL VIEW OF PLANT

Brine Storage and Evaporation

The storage tanks shown in Fig. 7 contain a combined capacity of one million gallons or 650 tons. From them the brine is pumped to the evaporators shown in Fig. 8.

These pans stand 86 feet high and are 22 feet in diameter. The calandria or steam belt is comprised in the first section above the working floor, which is thirty feet above the ground floor of the building. Reading from left to right, the pans are numbered 3, 2 and 1.

No. 3 is the low-temperature, high-vacuum pan and it is into this pan that the brine after a pre-heating in a single-effect 16-foot Manistee pan is pumped, together with a proportionate amount of mother liquor from the sumps in the crystallizing house.

FIG. 7.—BRINE TANKS

The liquors pass from No. 3 pan through the intermediate No. 2 pan into the high-temperature, low-vacuum No. 1 pan in a steady flow. From No. 1 pan the now concentrated liquors, having a specific gravity of 1.385 to 1.390, are pumped over to the crystallizing house. Exhaust steam from Terry steam turbines is fed to No. 1 vacuum pan from a mixing drum.

To the left of No. 3 pan is shown a rotary jet condenser. This pump, operated by a 500 hp. Terry steam turbine, functions both as a vacuum pump and condenser, handling the vapor from No. 3 pan. The condensed vapors and cooling waters are pumped from the condenser and returned to the spray pond by an auxiliary booster pump. Some 7000 gallons of condensed and

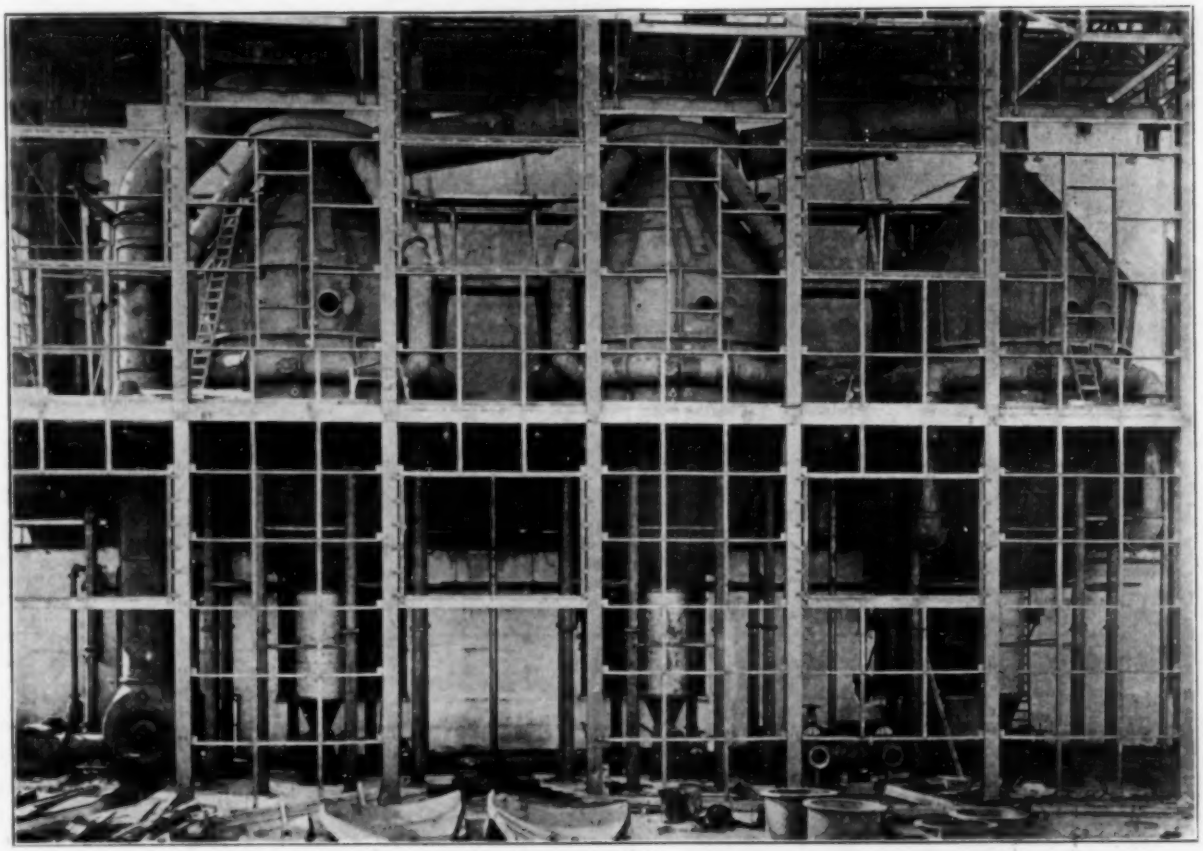


FIG. 8.—BATTERY OF MULTIPLE EFFECT EVAPORATORS

cooling waters are forced through the sprays every minute.

Upper Flue Sheet of a 22-foot Manistee Vacuum Pan

The men shown in the photograph, Fig. 9, are expanding the two-inch diameter, six-foot charcoal-iron flues into the upper flue sheet of the calandria. One

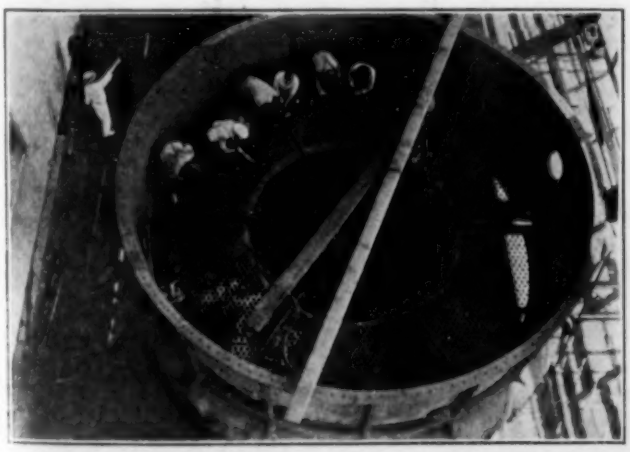


FIG. 9.—UPPER FLUE SHEET OF CALANDRIA

22-foot pan contains about three and one-half miles of such flues.

A propeller shaft, extending through the length of the pan from the top of the pan to well below the calandria, and making thirty revolutions per minute, increases the circulation of the heavy pan liquors through the flues; heavy mineral oil prevents foaming.

In Fig. 10 are shown the evaporator leg pipe and tailings elevator. These tailings-salt elevators handled roughly 350 tons of waste salts per twenty-four hours. These salts are dropped by gravity into waste-salt cones

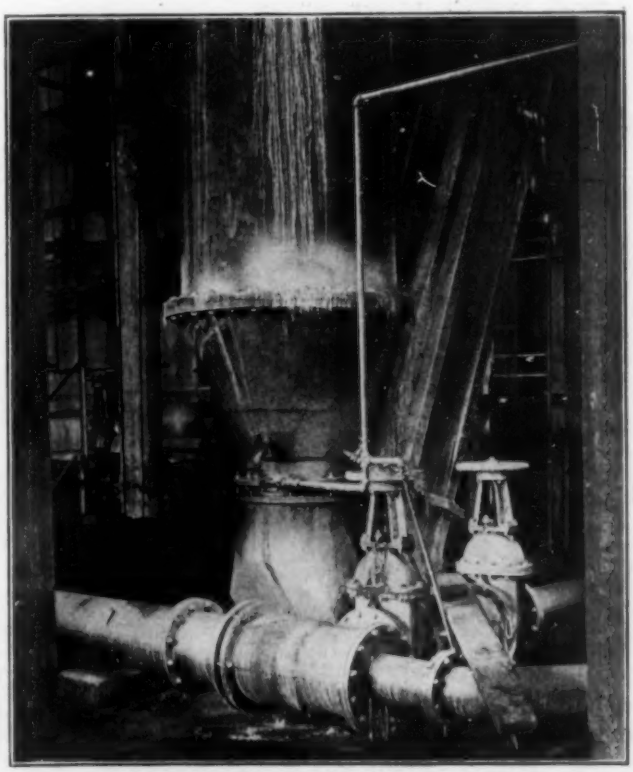


FIG. 10.—EVAPORATOR LEG PIPE AND TAILINGS ELEVATOR

from which they are flushed with brackish water back on to the lake.

In the background of Fig. 11 may be seen the Pelton-Doble water-wheel-driven pump with its set of connections for filling and draining the vacuum pans. It has a

FIG. 11.—PUMPS FOR CHARGING BRINE TO EVAPORATORS

capacity of 6000 gal. per minute. The suction and discharge openings are 16 inches in diameter.

By opening any two of the six valves shown in Fig. 12, the pans may either be filled with raw brine prior to starting a run; drained into large storage vats prior

FIG. 12.—VALVES CONTROLLING THE BRINE LINES

to boiling out (which in the present cycle is done after every run of thirty-six hours); filled with brackish water for boiling out to clean pans; or drained of same after boiling out has been accomplished. The rotary jet condenser used on the "high vacuum" pan is illustrated in Fig. 13, showing reduction gears and the 500-hp. Terry steam turbine for driving them. The booster pump for removing cooling and condensed waters is in the background.

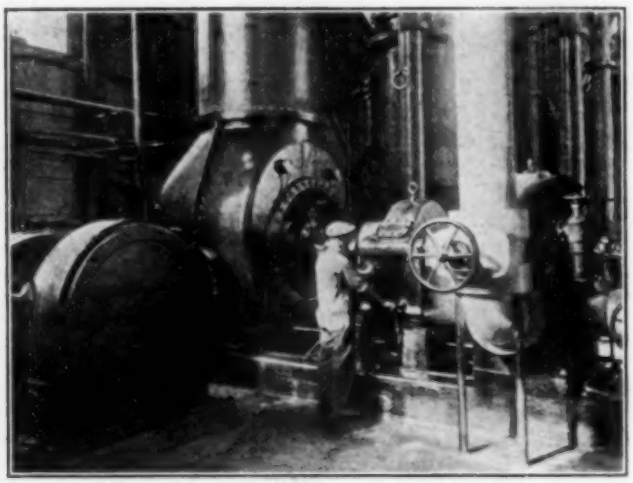


FIG. 13.—ROTARY JET CONDENSER

Fig. 14 shows a triple-effect unit of 22-foot Manistee vacuum pans as they appear when completed. They are insulated with two-inch corrugated air cell asbestos. On top of this is spread a layer of plaster about one inch thick, and on top of this is a covering of 10-oz. duck, the whole being finished off with a coating of white paint.

In the distance may be seen a part of the 16-foot

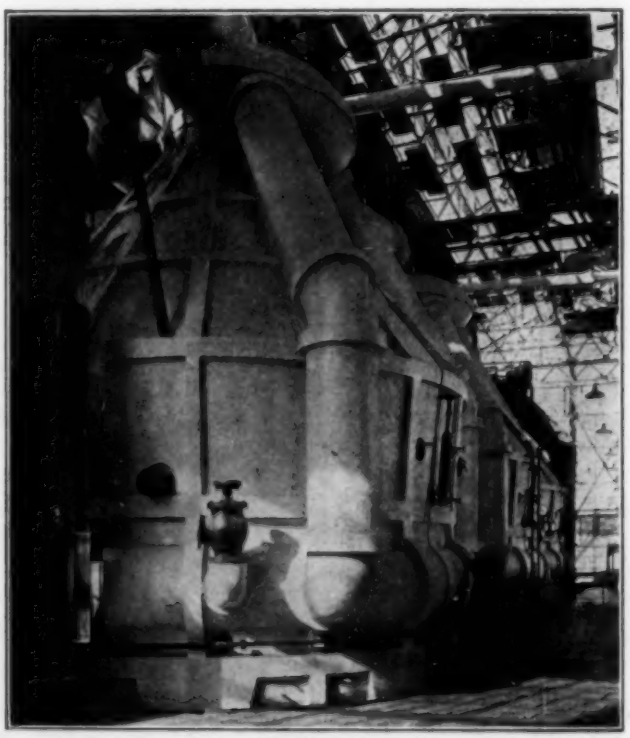


FIG. 14.—VACUUM EVAPORATORS SHOWING INSULATION

single-effect pan now used as a pre-heater for the raw brine fed to the No. 3 pan.

The interior of the crystallizing house is shown in Fig. 15. This picture shows two of four rows of crys-

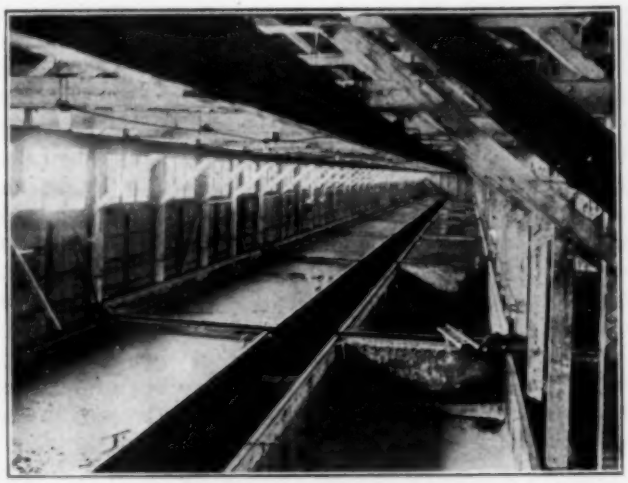


FIG. 15.—VIEW OF CRYSTALLIZING VATS

FIG. 16.—REMOVING POTASH FROM CRYSTALLIZING VAT

tallizing vats. These vats are 54 feet long, 15 feet wide and 6 feet deep. They hold 30,000 gallons of concentrated liquor. An average of 15 tons of crude potash salts is taken from each vat. There are 36 such vats in use for the one unit which is now operating.

Potash in the Crystallizing Vats

It takes from seven to eleven days for a vat to cool to near atmospheric temperature, depending on the time of the year. At present, during summer weather at Searles Lake, the vats are dropped at from 40 to 45 deg. C. In the winter when the nights are very cold

FIG. 17.—POTASH STORAGE FLOOR

the temperature of the vats drops more quickly, and the mother liquor is returned to the system at from 25 to 30 deg. C.

All of this has a big effect, not only upon the quantity and nature of the salts produced, but it also has a big effect upon the actual operation of the vacuum pans themselves.

The crude potash salts are carried from the vats to the drain floor in boxes of 2000 pounds capacity, which are operated by self-propelled electric hoists. The potash stays on this drain floor for about seven days before it is passed through a Stedman mill prior to being loaded for shipment.

Trona, Cal.

Zeolites as Potash Collectors

ACCORDING to Dr. F. W. Clarke, in the Data of Geochemistry, U. S. Geological Survey *Bulletin* 491, the average proportion of potassium to sodium in river waters is as one to four, while in sea water the ratio is one to thirty. In igneous rocks sodium and potassium are nearly equal, and in view of the greater solubility of most of the potassium salts it would seem as if the mysterious disappearing process began as soon as the rocks weather. The reason for this, as given by the same authority, is that ordinary soils, and more particularly clays, are able to remove a considerable proportion of potash salts from their solutions and that these are removed from natural waters as they percolate through the soil, or by the suspended silt carried through the streams. The sodium is not so largely withdrawn, so that its relative proportion in solution increases. Thus the metal with more soluble salts is deposited with the sediments while that with less soluble salts remains in solution. Experiments on Hawaiian soils by Crawley and Duncan show that a layer six inches thick will fix over 98 per cent of the potassium in a solution of potassium sulphate which is allowed to filter through it.

This feature of zeolites would point to a method of collecting potassium from river waters were it not for the fact that calcium and magnesium take precedence over alkali metals and that the latter form their substitution products only under mass action.

In analysis of red clay from ocean bottoms made on the Challenger expedition and later confirmed in the laboratory of the U. S. Geological Survey, it was noted that potassium was commonly but not always in excess of sodium. How to get these deposits up a mile or more from the floor of the sea would require the wit of another Herman Frasch, and even then the potash content of less than three per cent is not industrially promising. Glauconite, which is a hydrated silicate of potassium and ferric iron, is widely disseminated upon the sea bottom but most abundantly near the mud line surrounding continental shores. It is also found in the New Jersey green sands and it would hardly seem worth while to go under water for it when it may be found on dry land.

Extraction of Potash from Kelp*

By C. A. Higgins

THE recovery of potash from kelp, and the utilization of kelp ashes, principally as a fertilizer, is an art that has long been practiced. Many centuries before the German Syndicate began to market potash salts from their Stassfurt mines, the crofters around the rocky shores of Scotland and the Northern Coast of France had burned the drift kelp as a fuel and scattered the ashes over their land as a fertilizer. The great success which resulted from the use of this kelp ash on the land caused a rapid expansion in the business of kelp harvesting, until about the beginning of the 19th century, quite a flourishing industry had already sprung up.

The opening of the German potash mines, however, about the middle of the nineteenth century, began to flood the market with potash at a price far below that at which the old kelp burners could produce it, and although the kelp-potash industry still struggled along in isolated parts of the coast amongst the Scottish crofters, and to some extent in Japan, it may be said that the German production killed the kelp industry, which had up to that time attained fairly considerable proportions.

The outbreak of the present war, however, drove potash users to look for new sources of supply, and naturally one of the first to come to their attention was kelp. Previous to the outbreak of the war many writers had drawn attention to the huge perennial beds of kelp which grow practically uninterrupted all along our coastal waters on the Pacific side, from the Mexican line to Alaska, and around the scattered groups of islands which lie close to the California shore. These vast fields of kelp seemed to offer inexhaustible supplies of potash, which according to the preliminary survey made by the Government, bade fair to supply far more than the normal requirements of our country for the indispensable muriate of potash. All that remained was to devise economical means for harvesting these vast beds, and drying and reducing the kelp to a suitable condition for transportation and use as a fertilizer. Within a few months, therefore, of the cutting off of the German muriate, various large companies were prospecting the Pacific coast for suitable sites on which to erect plants for the harvesting and extracting of potash from the Pacific kelp.

Old and New Methods of Harvesting

The earliest attempts at harvesting were very crude and involved a good deal of manual labor. Men in flat-bottom scows would reap the weed by hand with large sickle knives and burn it in a rather primitive way. The ash was afterward sold to the big fertilizer companies at a price based upon the potash content, which generally ranged around 15 per cent K_2O. Later, however, modern methods were installed for the harvesting of kelp. Large flat-bottom, steam- or gasoline-propelled scows were equipped with a mechanical reaping device and band conveyors which cut the kelp and conveyed it in one operation into the tanks aboard the harvesting vessel, at very much less expense than that involved in the old method of handcutting. These harvesters, when filled, then proceeded to shore under their own power and discharged their contents into hoppers at the plant, which in turn fed series of mechanical dryers where the kelp leaves were dried and partly incinerated by passage through revolving drums heated by oil burners. The dried incinerated kelp leaves were then ground and sacked and ready to be shipped to the fertilizer factory. Some attention is paid in the drying process to insure that a minimum of the potash and nitrogen content of the kelp is lost by the destructive distillation effect of the drying equipment. That, briefly, is the method now in use in plants where potash is considered as the only valuable constituent of the kelp. Experience has shown, however, that this process of producing potash and realizing the values of kelp is very expensive, and will exist possibly just so long as the war and the present high price of potash last.

High Cost of Potash from Kelp Must Be Reduced by By-Products

A few figures will show the status of the kelp-ash industry in this regard. Using the modern harvesting methods that I have already briefly touched upon, experience shows that it costs around $1.10 to harvest and bring a ton of kelp leaves ashore. Analyses show that the average potash content of the raw kelp as harvested in California coastal waters is about 1.3 per cent K_2O, which means that it costs about $85 to bring in the green kelp equivalent of 2000 lb. of 100 per cent K_2O. On top of this, of course, has to be added the costs of drying these kelp leaves, which contain about 90 per cent of moisture, and by reason of their gelatinous and cellular structure, present quite a problem in dessication. All indications seem to point very clearly to the fact, therefore, that any industry which looks to the production of potash from kelp on a permanent peace-time basis, must reduce its cost very considerably, or produce valuable by-products in the same process which in turn will effect a reduction in the cost of the potash.

Along these lines certain investigators have suggested as far back as a century ago that the peculiar algin bodies present in kelp might be profitably recovered and used in certain directions in place of gelatin, for the sizing of paper and textiles, the proofing of cloth, and in the production of rubber substitutes and admixtures. Another interesting suggestion is that of Prof. T. C. Frye, who made a conserve by first leaching out the potash and soluble salts and afterwards soaking the kelp in cane sugar solution flavored with lemon. In Japan a kind of sour pickle with vinegar is made from the fleshy parts of the kelp. The kelp fibre when compressed and dried also forms a hard substance resembling ebonite or vulcanized fibre, and at least one concern is working along these lines at the present time. The production of by-product iodine from kelp, however, has long been a practical proposition, although hampered somewhat by the competition of by-product iodine from the Chilean nitrate fields.

The biggest practical advance in the economical production of potash from kelp was marked in the year 1915, when the Hercules Powder Co. started the construction of large gasoline-propelled marine kelp harvesters and a factory located near San Diego, California.[1] This equipment was designed primarily for the produc-

*Report of an illustrated address at the Fourth National Exposition of Chemical Industries, New York, Sept. 25, 1918.

[1]Illustrated article in this journal, June 1, 1918.

tion of acetone, potash and iodine from kelp. Kelp as a source of acetone was something entirely new to chemical industry, and chemists all over the world have watched the growth and development of the undertaking with great interest. The plant since its inception has rapidly increased the number and range of its products, and placed upon the market some new materials which are full of industrial promise.

Reduced to its simplest terms, the basic principle of this process of kelp reduction lies in the destruction of the cellular tissue of the kelp leaf by fermentation, bringing the potash into solution, and producing acetic acid as the product of the fermentation of the kelp leaf. The acetic acid is neutralized with limestone, giving calcium acetate, potash, and iodides in the solution.

The products chart, shown in Fig. 1, will give a general idea of the operations at this plant and serve as an introduction to the more detailed description that follows. With this I think we can outline quite clearly the

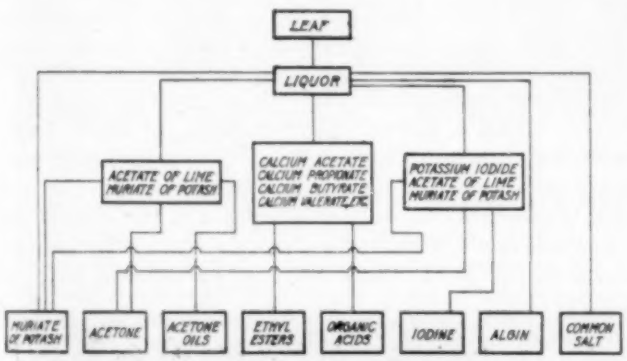


FIG. 1. KELP PRODUCTS CHART

principal steps involved and the products produced in the fermentation of kelp. The kelp is harvested and brought to the plant, pumped from the tank barges into the fermentation vats where it is allowed to ferment until the kelp leaf goes into solution and a liquor is obtained which on evaporation and concentration yields, at various stages, three intermediate salts.

Separation of Potassium Chloride

The first intermediate salt, consisting of a mixture of acetate of lime and muriate of potash, is heated in regular acetone retorts, which produce acetone from the acetate, leaving as residue muriate of potash and calcium carbonate, from which the high-grade muriate is separated by leaching and subsequent crystallization. The fractionation of the crude acetone yields a certain amount of light and heavy acetone oils, in addition to the C. P. acetone.

Intermediate salt No. 2, consisting of the calcium salts of the higher fatty acids, is mixed with alcohol and sulphuric acid and the corresponding ethyl esters produced by well-known methods. These esters are easily separated by fractionation. Ethyl acetate, ethyl propionate and ethyl butyrate in commercial quantities are now on the market from this source and are finding very extensive application as solvents in the soluble-cotton industry, in the manufacture of artificial leather etc.

Intermediate salt No. 3, consisting principally of potassium iodide, is treated with chlorine and the precipitated iodine dried and resublimed.

Gelatin Substitute, Ammonia and Medicinal Chemical Also Recovered

The last of the final products shown on the chart is algin. This substance is at the present time being produced from the residual unfermented leaves which are screened from the liquqor coming from the fermentation vats. These leaves are treated with sodium carbonate which extracts the algin in the form of a soluble sodium salt which is afterwards precipitated and purified. So far, but little progress has been made in the commercial development of the use of this algin as an article of commerce. The perfection of extraction manufacturing methods however, and the increasing cost of gelatin and vegetable gums, leads to the conclusion that this material may find a very extensive use in the future.

In addition to the foregoing valuable products, promising experiments are now in hand whereby ammonia, valeric, and caproic acids are being recovered as by-products in the fermentation of kelp. Nitrogen combined as ammonia exists to the extent of about 0.2 per cent in kelp, and is left in the liquor after fermentation of the leaf. Valeric acid as the isoform is much needed at the present time in the treatment of nervous disorders, the supply of the valerian root from which the medicinal valerates were formerly made having been almost entirely cut off.

Kelp Potash Cannot Compete with Unrestricted European Supplies

Sufficient has been said I think to indicate that the kelp industry from being conceived solely as a source of fertilizer potash will eventually develop along the lines of fine chemicals with high grade muriate somewhat in the position of a by-product. It is doubtful whether the total potash production of all the kelp-harvesting concerns at the present time amounts to more than about 25 tons a day on the basis of 80 per cent muriate of potash. Of this, more than a half is of a high grade of purity about 95 per cent KCl, and is produced not by the original method involving the incineration of the kelp, but by the fermentation process already referred to.

It may be a little early yet to speak definitely of the future of the kelp industry and its future bearing on potash. Certain it is that with kelp-production factories extending all along the Pacific Coast, our domestic demands for potash cannot be met thereby. Certain it is, too, that kelp solely as a source of potash will never compete with unrestricted supplies from Europe or even with that recovered in modern cement or blast-furnace practice. The utilisation of kelp in such a way, however, as to realize on all its other possible values, some of which have been touched upon may help to render the users of high-grade potash for chemical purposes outside of the fertilizer trade, independent of foreign supplies.

Soluble Potash from Feldspar

B. F. Halvorsen of Christiania, Norway, patents the process of heating a mixture of finely ground feldspar, cyanamide and alkali salts to 650 deg. C. in the presence of superheated steam, whereby he gets ammonia and a good yield of soluble potash, which is refined by crystallization. (Eng. Pat. 107,012, May 30, 1917.)

Potash as a By-Product

Southern Iron Ores and Fluxes Considered as a Domestic Source of Potash in Large Quantities—Analysis of Raw Materials—Estimated Cost of Operation—Probable Recovery and Profits

By J. S. GRASTY
Geological and Chemical Engineer, Charlotteville, Va.

IT IS, of course, a matter of general information that prior to the war Germany supplied practically all the potash salts used in the world. With but small reserve supplies of potash and the German supply entirely cut off this country has in consequence faced a serious shortage in this material so essential as a fertilizer. The best indication of this fact is that high-grade potash salts are now quoted at approximately $350 to $425 per ton, whereas the normal price before the war was $35 to $40 per ton. Further evidence on this point is given in Table I on imports of potash salts:

TABLE I—IMPORTS OF POTASH SALTS

	Pounds	Value
1912	622,179,164	$10,692,285
1913	612,514,916	10,805,720
1914	485,818,459	8,743,973
1915	170,550,450	3,765,224
1916—January to April	3,091,250	379,260

These figures show that before the war over 600,000,000 pounds of potash salts were imported annually. Of this quantity approximately 500,000,000 pounds was in the form of chloride and 100,000,000 pounds in the form of sulphate, both of which salts are used especially for fertilizers. In 1915 the imports were less than 200,000,000 pounds, 90 per cent of which was used by the fertilizer industry.

If our normal annual consumption of potash be represented by the figures for 1912, there was in 1915 a shortage of over 450,000,000 pounds, and judging from the figures this shortage was much greater in 1916.

Table II gives the potash production of the United tates for 1917:

TABLE II—POTASH PRODUCTION, UNITED STATES, 1917

Sources	Number of Producers	Available K_2O, Short Tons
Mineral Sources—		
1. Natural brines	10	20,652
2. Alunite (refined salts, crude and wasted alunite)	3	2,402
3. Dust from cement kilns	3	1,621
4. Dust from blast furnaces	3	185
Organic Sources—		
1. Kelp	10	3,572
2. Molasses residue from dist.	4	2,846
3. Wood ashes	36	424
4. Evaporated Steffens water from sugar refineries	5	359
5. Evaporated wool washings and insol, industrial waste	3	305
	82	32,366

According to the U. S. Geological Survey, the production of potash for the first six months of 1918 was between 20,000 and 25,000 tons of K_2O, and it is estimated that the total production for the year will reach 60,000 tons. On the other hand, the Bureau of Soils estimates that the cement plants of this country should be able to produce more potash alone than the total estimate for 1918[1]. However, it should be remembered that this is only 25 per cent of our normal requirements.

[1]Commenting on this the editor of the *Manufacturers' Record*, Sept. 22, 1918, calls attention to the fact that the blast furnaces could probably produce 200,000 tons of K_2O per year, at the same time obtaining a cleaner gas for their stoves and gas engines.

Serious Shortage of Potash

The present condition of potash shortage is so serious that both the U. S. Geological Survey and the Department of Agriculture have directed special attention to the investigation of new sources of supply. Borings, with practically unsuccessful results, have been made in the "Red Beds" of the West and elsewhere in the endeavor to locate suitable deposits, and to determine whether or not potash salts are to be found in association with beds of common salt in sufficient quantity to be of commercial importance, but, as indicated, so far the results have not been satisfactory.

The Bureau of Soils of the Department of Agriculture has been investigating the extraction of potash from the sea weeds (kelps) of the Pacific coast. This Bureau has also investigated the various processes of the extraction of potash from feldspar etc. Important work is also being done by Dr. T. Poole Maynard of Atlanta, Ga., in

TOP BED ON RESER MOUNTAIN

investigating methods of recovery of potash from the sericite schists and slates of Georgia.

The conclusion is definitely reached that a potash industry in order to be successful must be considered strictly from the point of view of cost of production. Many enterprises which are now producing at a profit cannot expect to survive during the post-war period. In fact the only potash industries for which success is assured are those which depend upon recovering potash as a by-product, and therefore this desired end can be attained in the treatment of volatilized products of Portland cement plants and the gases of blast-furnaces by making use of the Cottrell processes of electric precipitation.

Too much emphasis cannot be placed upon the point

that potash produced in this country must be able to compete with that produced in Germany after the war. Potash recovered as a by-product should be produced at a price as low as $15 per ton after all charges have been deducted. Also the probable tonnage and stability of the industries of which potash is a by-product must

UPPER SEAM AND PART OF LOWER SEAM AT EUMAUHEE

be taken into consideration. As previously indicated, there are two extremely important sources of by-product potash in this country, namely, cement plants and iron blast-furnaces. At the present time considerable quantities of potash are being produced as a by-product of cement plants and large profits are being earned.

Very little, however, has as yet been recovered from iron blast-furnaces, although such plants offer a field for the use of processes of recovery as good as, if not better than, cement plants. Nevertheless, sufficient work has been done by Wysor[2] of the Bethlehem Steel Company, Porter of the Security Cement & Lime Company and others to prove that blast furnace gases do contain potash which, in many cases, can be recovered and especially so when employing iron ores which are high in potash.

Furthermore, blast-furnace gases should be cleaned of their suspended particles anyway, in order that the efficiency of the furnace may be increased. It has been found that the best way to accomplish this is by use of the Cottrell process, which in addition to cleaning the gases also recovers the potash in marketable condition. Taking into consideration the fact that it is highly advisable from an operating point of view to increase the efficiency of blast-furnaces by employing the Cottrell process to clean the gases regardless of the recovery of potash which is effected at the same time, obviously the potash so recovered is obtained at a practically negligible cost. As a matter of fact, furnace companies could afford to pay well to have their gases cleaned and give the recovered potash to the party doing the cleaning.

Iron Blast-Furnaces as a Source of Potash

Potash recoverable from iron blast-furnaces originates in the iron ore, coke, limestone and other fluxing agents charged into the furnace; a small amount of potash leaves the furnace in the slag and in the gases. By use of the Cottrell process the gases pass through an electric precipitator before they reach the stoves. With a given slag volume, the amount of potash carried from the furnace in the slag is more or less constant, or rather, it does not exceed a certain quantity. Therefore, of the total amount of potash charged into the furnace, obviously the greater part can be recovered from the gases. On the other hand, it is true that most iron ores, limestones and cokes do not contain much potash; consequently if large results in the matter of potash recovery are to be obtained it follows that one or more of the raw materials employed should be high in this substance.

As to the potash content of fluxing materials, either limestone or dolomite, and of coke there is offered a wide field for investigation; but the information so far available points to the conclusion that the potash content of these is in general more or less constant and fairly low as compared with the variations in potash content to be found in certain of the iron ores. After all, as goes without saying, it is the potash in the iron which is most important, although it is also obvious that

SOUTH SIDE EUMAUHEE OPENING

if the fluxing materials and coke be also high in potash that is very desirable too. Furthermore, the presence of potash in the fluxing stone, coke or iron ore has an additional value because of the fact that it acts as a desulphurizer.

Only Large Tonnages Are in Alabama

An investigation of the potash content of different iron-ore deposits in the United States as reported by others and as determined by the present writer forces the conclusion that the only large tonnages of potash-bearing iron ores known in this country occur in the State of Alabama. These occurences are found in the

[2] "Potash as a By-product from the Blast Furnace," by R. J. Wysor, *Transactions* of the American Institute of Mining Engineers, Vol. LVI, p. 257.

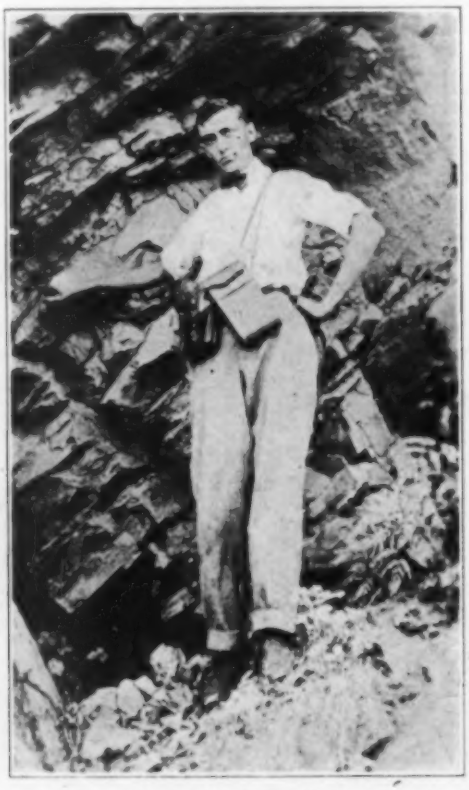
eastern part of the State, in Talladega and Shelby counties, and may be assigned on a most conservative basis an aggregate of considerably over one hundred million tons of ore which is much higher in metallic content than the Clinton ores, the latter being the chief reliance of the blast-furnace industry of Alabama.

These relatively high-grade Cambrian ores occur as beds in the Weisner formation of Cambrian age in three districts, the Weewooka, Eumauhee and Columbiana. Metamorphism has altered the Weewooka and Eumauhee ores to a specular or gray hematite, while the Columbiana is bright red. The quality of these ores and their range in composition as compared with other Alabama ores are given in Table III.

TABLE III—ALABAMA IRON ORES

	Range in Composition, Per Cent, Fe	Potash, Per Cent
Weewooka and Eumauhee	40–52	1.50–3.00
Columbiana	44–46	1.00–1.25
Alabama brown ores	40–48	0.20–0.40
Alabama red or Clinton ores	34–50	0.15–0.25

Ore has been mined and sold from all three of the Cambrian ore occurrences mentioned above, which, by



ORE BED AT EUMAUHEE

the way, are controlled by different interests, and has been smelted with most satisfactory results—that is, in all cases where it has been properly mined free from slate. This is a point which seems worth mentioning for the reason that in one instance, at Tallasseehatchee creek, the mining was conducted in such a way that the ore shipped was of rather low grade because of careless mining resulting in a large and unnecessary admixture with slate. Most of these Cambrian ore beds are, however, entirely free from slate partings. These deposits are within about forty miles of Birmingham, with other furnaces quite near at hand in the same eastern section of the State.

Referring to Table III, it will be seen that the Cambrian ores, as compared with the Clinton and brown ores of Alabama, are exceedingly high in potash. The value of their high potash content can probably best be emphasized by pointing to the fact that at the Portland

BOTTOM SEAM, NORTH SIDE EUMAUHEE

cement plant of the Security Cement & Lime Company at Hagerstown, Maryland, whose deposits the writer located and whose plant has been so successfully managed by Mr. J. J. Porter, the shaley limestone used ranges in K_2O from 0.75 to 1.10 per cent. The net profits obtained in recovering potash at this plant using the Cottrell electric precipitator amounted during the year 1917 to over $200,000. Even this large profit, which is enormous considering the required outlay for equipment and operation, will probably be exceeded by a blast-furnace treating a corresponding quantity of material; that is, assuming the blast-furnace runs on these high-potash ores in sufficient quantity and at the same time employs the Cottrell process for catching the potash. It will be seen how closely the comparison holds between a 3000-barrel cement plant, the capacity of the plant at Security, and a 200-ton blast-furnace when it is stated that both handle approximately the same quantity of raw material.

Table IV brings out the potash value to be recovered using Cambrian ores as compared with Clinton ores of different grades:

TABLE IV—VALUE OF RECOVERABLE POTASH FROM CAMBRIAN ORES

Recovery, per cent...	40	45	50	55	60
Value	$467,247	$525,643	$584,058	$642,464	$700,870
Recovery, per cent...	65	70	75	80	....
Value	$759,276	$817,681	$876,087	$934,494	....

Mr. Charles Catlett of the War Industries Board states[3] that the average analysis of a number of samples of these specular hematites shows a potash content of 2.08 per cent, and he calls attention to the fact that this is over seven times the potash contained in the mixture used by Mr. Wyser at the Bethlehem Steel Company's plant.

Table V showing the cost of producing pig iron, depending upon the kind of ore used, and the estimated results in potash recovery and profits therefrom by the erection of a Cottrell electric precipitator at a 200-ton

[3] *Manufacturers' Record*, March 29, 1917.

iron blast-furnace, was prepared in collaboration with Mr. Linn Bradley, Chief Engineer of the Research Corporation. In this connection it should be stated that the Research Corporation of New York City owns the patents covering the Cottrell process as applied to the recovery of potash from iron blast-furnaces and for other uses except as applied to Portland cement plants,

WEST SIDE MAIN CUT, TALLASSAHATCHEE

which rights are owned by the Western Precipitation Company. Mr. Bradley having had charge of installations of Cottrell electric precipitators for the Research Corporation since its organization, and having given his attention to the recovery of volatilized products of various sorts by use of these processes, any statement from him on these subjects is authoritative.

TABLE V—ESTIMATED RESULTS OF COTTRELL ELECTRIC PRECIPITATOR INSTALLED AT A 200-TON IRON BLAST-FURNACE

Items	Coke	Limestone	Dolomite	No. 1 Camb. Ore	No. 2 Red. Ore	No. 3 Brown Ore
Material cost, long ton		$1.00	$1.00	$5.00	$2.00	$3.50
Material cost, short ton	$8.00					
Content silica, per cent	8.70	2.00	1.25	19.20	18.00	19.50
Content alumina, per cent.	5.00	1.00	1.00	4.80	5.00	3.80
Lime-magnesia	0.30	53.00	58.88	1.30	18.00	6% H_2O
Potash	0.30	0.30	0.50	1.80	0.20	0.20
Iron	1.70	0.00	0.00	49.80	34.00	42.00
Ore required for one long ton of iron, pounds				4,398	6,365	5,212
Percentage of burden				46.07	50.93	46.87
Coke required for one ton of iron, pounds				2,700	4,480	3,000
Percentage of burden				28.29	35.85	26.98
Dolomite required for one ton of iron, pounds				2,448	1,652	2,909
Percentage of burden				25.64	13.22	26.15
Material cost per ton of iron—coke				$10.80	$17.92	$12.00
Material cost per ton of iron—ore				9.82	5.68	8.24
(Dolomite 90 lb.—limestone 100 lb.)—stone				$1.09	$0.74	$1.30
Total material cost for one ton of iron				$21.71	$24.34	$21.54
Furnace capacity in tons iron output per day				230	180	220
Total material cost per day				$4,993	$4,381	$4,739
Average value per ton iron produced				$33.00	$31.50	$33.00
Gross value of output of iron per day				$7,590	$5,670	$7,260
Gross profit on iron output per day (Labor, overhead, etc., not considered)				$2,597	$1,289	$2,521
Gross profit on iron output per year, as above				$908,950	$451,150	$882,350
Total potash content of burden per ton of iron, pounds				99.50	34.43	33.97
Deduct for losses in slag and elsewhere				20.96	31.28	23.46
Potash remaining, unknown portion, collectible, pounds				78.54	3.15	10.51
Gross value potash at present price $5 per unit 350 days taken as one year's operation:						
Equal to 25 per cent water—soluble				$395,154	$12,403	$50,579
Equal to 35 per cent water—soluble				553,216	17,364	70,811
Equal to 40 per cent water—soluble				632,247	19,844	80,927
Estimated operating cost per annum				165,000	165,000	165,000
Estimated net value potash per annum—present 25 per cent				230,154		
Estimated water soluble percentage—35 per cent				388,216		
Estimated water soluble percentage—40 per cent				467,247		

It is Mr. Bradley's opinion, backed by data which he has assembled, that a 40 per cent recovery of water-soluble material may be confidently relied upon as a minimum, though he admits that in practice much larger yields are attained, since, for instance, Mr. Catlett, who has served as chemical advisor of the Security Cement & Lime Company, considers an 85 per cent recovery conservative[4]. Mr. Catlett also estimates that under present conditions potash recovered at a blast-furnace using the Alabama Cambrian iron ores would be worth from $12 to $15 per ton of iron produced, which means in potash values alone for a 200-ton furnace $2400 to $3000 per day.

As is well known, it is the trade custom to sell potash on a basis of the units of pure potash, a unit being 20 pounds. The present market price for agricultural potash is around $5 per unit as against 60 and 70c. during the pre-war period. As to this matter of prices, it is the opinion of those best acquainted with the industry that the price of potash will remain relatively high for a number of years after the war.

Estimated Costs and Recoveries

The cost of collecting potash by use of the Cottrell process[5] is estimated in Table VI.

TABLE VI—COST OF COLLECTING POTASH

	Per Unit K_2O
Collection, including labor, power, repairs and laboratory	$0.14
Packing and shipping	.08
Total operating cost, exclusive of depreciation, royalty and salt addition	$0.22

The cost of the salt adition—about 25c. per unit of potash—is not a necessary element, and can be omitted

EAST SIDE MAIN CUT, TALLASSAHATCHEE

whenever price conditions are such as to give an unsatisfactory margin of profit.

The following figures[6] taken in connection with the calculated recovery will give a basis for estimating cost in any particuler case:

> Labor required for operation—1 foreman, who can also supervise packing and loading, and 1 or 2 operators per shift—about $12 per day.

[4] *Manufacturers' Record*, March 29, 1917.

[5] All costs given in this paper are recent and are considered correct, but to be conservative from 10 to 15 per cent. might be added to the total.

[6] All figures on operating costs here given have been supplied by Mr. Porter and are based on actual practice at the 3000-bbl. Portland cement plant of the Security Cement & Lime Co. Inasmuch as a 200-ton iron blast-furnace, according to Southern furnace practice, handles approximately the same quantity of raw material as a 3000-bbl. cement plant, the cost of operation of a Cottrell electric precipitator should be approximately the same in both instances.

Laboratory—1 additional chemist, say $4 per day.
Power—1300 kw.-hr. per day for 3000-bbl. plant based on dry collection plant—about $12 per day.

Operating costs and profits would be about as in Table VII.

TABLE VII—OPERATING COST

		Per Bbl. Clinker
Labor	$27.00 per day–	$0.0090
Power	25.00 per day–	.0083
Repairs	8.00 per day–	.0027
Laboratory	120.00 per mo.–	.0014
Salt addition		.0220
Total		$0.0434

	Present Price	Assumed Post-War Price
Sales price per unit potash	$4.5000	$1.0000
Value potash collected per bbl. clinker	.4675	.1039
Operating cost per bbl. clinker	.0434	.0434
Operating profit per bbl. clinker	$0.4241	$0.0605
Operating profit per year based on full operation of cement plant	$458,038	$65,340

For the benefit of those who wish to estimate the probable recovery of potash at a given plant, the potash content of whose raw materials has been determined by analysis, and the percentage lost in the slag having

ORE BED ON HEOCPACK MOUNTAIN

also been determined, the method of calculation here indicated, which is adapted from that used by Porter for cement, is submitted:

Let A equal per cent of potash in furnace burden, i.e., average of K_2O in ore, stone and coke.
Let B equal per cent potash in slag. This ranges from 0.0017 to 0.0065 per cent, average being 0.0039 per cent.
Let C equal liberation of potash. This equals:

$$\frac{9500A - 3800B}{9500A}.$$

Let F equal lb. potash recombined in slag. This compares with potash combined with clinker in manufacturing cement as follows: the range in per cent in cement is from 0.002 to 0.0039, and in slag from 0.0017 to 0.0065, the average in the latter being 0.0039.
Let P equal per cent potash precipitated in treater. This should be 80 to 90 per cent of the total entering.
Assume 9500 lb. burden actually used to produce one ton pig iron, and yielding 3800 lb. in slag.
Pounds potash entering furnace per ton pig iron equals $9500A$.
Pounds water soluble potash entering precipitators per ton pig iron equals $9500AC - F$.
Pounds water soluable potash collected in treaters per ton pig iron produced equals $(9500AC - F) \times P$.

If the average furnace burden be, say, one per cent potash and the loss in the slag 0.0039 per cent., or about 14 lb. per ton of pig iron, then the potash liberation will be about 85 per cent of the total present, and 3.29 units of potash; i.e., 65.43 lb. of potash per ton of pig iron will be produced. The value of a unit of potash is now over $5, being in fact nearer $6; but taking it at $5 per unit, the total value of potash produced at a 200-ton furnace will amount to approximately $3000 per day. This, however, is assuming that the Cottrell process will effect a recovery such as is experienced in practice, varying from 80 to 90 per cent. But assuming Bradley's minimum of 40 per cent water-soluble recovery, then the total net profit per annum for a precipitator installed at a 200-ton blast furnace—after deducting liberally to cover cost of operation, complete amortization the first year, interest on investment etc., and considering only the positively water-soluble material, *i.e.* 40 per cent—should be approximately $500,000, a result which is most amazing, but which reflects the present scarcity of potash as expressed by the prices now obtaining.

Large Production Necessary to Prevent Future German Monopoly

However, whether maximum profits be attained or not, it should be borne in mind that money so invested would be largely instrumental in giving us complete independence of Germany as a source of potash. Furthermore, no one knows how long the war is going to last, but every one knows that potash is an important plant food. This being the case, and with food and other plant products playing so large a part in winning the war, it is undoubtedly a patriotic duty to push the recovery of potash as a by-product energetically and to the limit. Raw materials high in potash are known, they are well located and available in large quantities; the Cottrell process has been thoroughly worked out, and the recovery of potash by its use, having already passed through the early experimental stages, has been fully demonstrated to yield satisfactory results. It is also highly important to establish the potash industry on a profitable basis in the United States in the near future, so that Germany cannot claim her former monopoly of potash when peace is restored. In view, therefore, of these pertinent facts, those of us who fail to take active steps now in this regard are slackers indeed.

The Sylvine Deposit in Alsace

A potassium chloride brine containing very little magnesium, the latter having been leached out during formation, was discovered near Mulhausen in Alsace in 1904, when deep borings were being drilled in testing out this locality for petroleum. In 1909 the first mining shaft was sunk and in the following year, 37,000 tons of potash salts were produced. The industry grew very rapidly and in four years, twelve mines were being operated. The Prussian Potash Syndicate decided to allot to this territory one twenty-fifth of the entire German production of ten million tons, so as to curtail the development of new mines. The extent of the deposit is not definitely established, although about seven square miles of sylvine from six to thirty feet thick, containing one billion cubic yards and one and a half billion tons of crude salts of 22 per cent K_2O analysis has been located.

A Wet Process for Extracting Potash from Cement Dust

A Detailed Description of a Humidifying Process for the Precipitation of Potash-Bearing Dust from Cement Kilns, Together with Drawings of a Unique Condenser-Evaporator Set Made of Reinforced Concrete

BY J. G. DEAN
Chemical Engineer, Southwestern Portland Cement Co.

ONE TON of potassium sulphate per day is being made at the Victorville, Cal., plant of the Southwestern Portland Cement Co. This is but one feature of a very interesting plant, the details of whose design and operation are largely due to their mechanical engineer, Mr. L. D. Gilbert. The potash plant now operating is hardly more than an experimental installation, and was installed at a cost of approximately $25,000. However, the modest plant shown in Fig. 1, is rapidly paying for itself, and at the same time is yielding information which is being utilized in the design of a more balanced installation to make a better recovery of water soluble potash on the entire kiln effluent.

General Features of the Cement Plant

It may be interesting to preface the discussion of the potash recovery system by a brief note on the design of the cement plant, which itself is an example of modern practice, being built in 1915 and 1916, beginning operation in September, 1916. The rock, which is a shattered limestone, impregnated with seams of clay, is steam shoveled at the quarry and delivered by standard gage railroad five miles long to the coarse crushing department. Here the rock is broken by a 36 by 60 Allis-Chalmers Fairmont roll crusher, and then delivered to a No. 7 Jumbo Williams mill, which discharges material at about ½-inch size. The discharge from the Fairmont roll crusher may be screened when desired, and the fine screenings washed to remove some clayey material, since the natural product is somewhat deficient in lime. The crushed rock is then elevated to storage bins of 450 tons capacity.

The fine grinding department operates two ten-hour shifts, the rock being wet ground in an 8-ft. Allis-Chalmers preliminator followed by a No. 18 F. L. Schmidt tube mill. The latter delivers a slurry containing 35 to 37½ per cent of water, the solids in suspension running 90 to 94 per cent through 200 mesh.

This slurry is then pumped into one of a series of eight round storage tanks, 16 ft. in diameter and 36 ft. high, containing 225 tons of solids—sufficient for 18 hour's burning. After this tank has been filled, it is agitated by compressed air for a period of 2 hours, sampled and analysed for CaO and total loss on ignition. Any adjustment necessary for correct chemical composition is then made by drawing proportional volumes from two or more of these storage tanks, delivering the mixture to a supply tank, which is one of the series shown to the right of the kiln in Fig. 2 exactly similar to the storage tank. When this is filled it is air-agitated, check-analysed, and is then ready for delivery into the kiln.

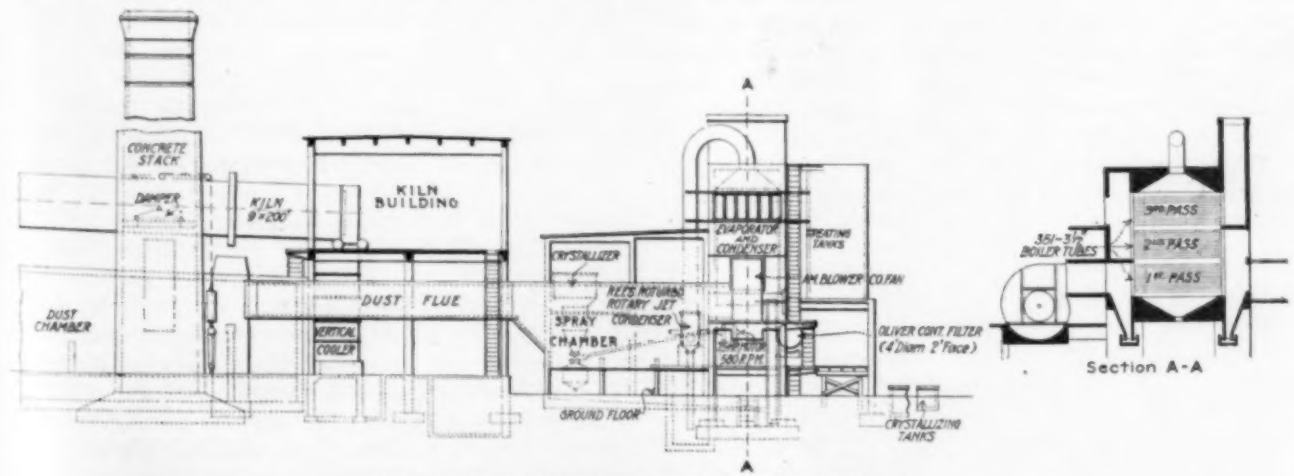


FIG. 1.—EXPERIMENTAL POTASH INSTALLATION

This kiln, (Fig. 2), is 9 ft. in diameter and 200 ft. long, jointed in the middle, oil burning, and capable of producing 1000 barrels of clinker in 24 hours. The latter is dug from the discharge pile by a clam shell and spread in longitudinal ridges by a locomotive crane running on a track through the middle of a concrete storage-bin, 318 ft. long and 66 ft. wide. The same crane reclaims the material for the finish department by digging across the bin at right angles to the bedding, this method of handling insuring a very well mixed clinker. Grinding is done in an Allis-Chalmers 7-ft. by 22-ft. Compeb mill, from which the cement is discharged and stored awaiting sacking and shipment in a series of bins, 27.5 ft. in diameter and 65 ft. high, each having a capacity of 10,000 barrels.

Kiln Dust

As shown in Fig. 2, the kiln is mounted directly above a concrete dust chamber 12 ft. wide, 14 ft. high and 200 ft. long. Since the wet process was to be used, no great amount of dust was expected, so the chamber was made with a flat bottom and no mechanical device installed to handle the settlement. However, it was found that approximately 3 per cent of the solid charged as slurry was recovered in the dust chamber—that is to say, about 270 tons of finest dust had to be shoveled out every month. As shown by the curve, Fig. 3, analysis of this material returned 1.4 per cent water-soluble K_2O at the kiln end, rising to 2.5 per cent at the stack end. Fig. 3 also shows that the fineness increased progressively, as would be expected; near the stack practically all of the material would pass a 200-mesh screen. The quantity line is approximate, indicating that there is a much greater amount of the low-grade, coarser material than of the finest, higher-potash dust.

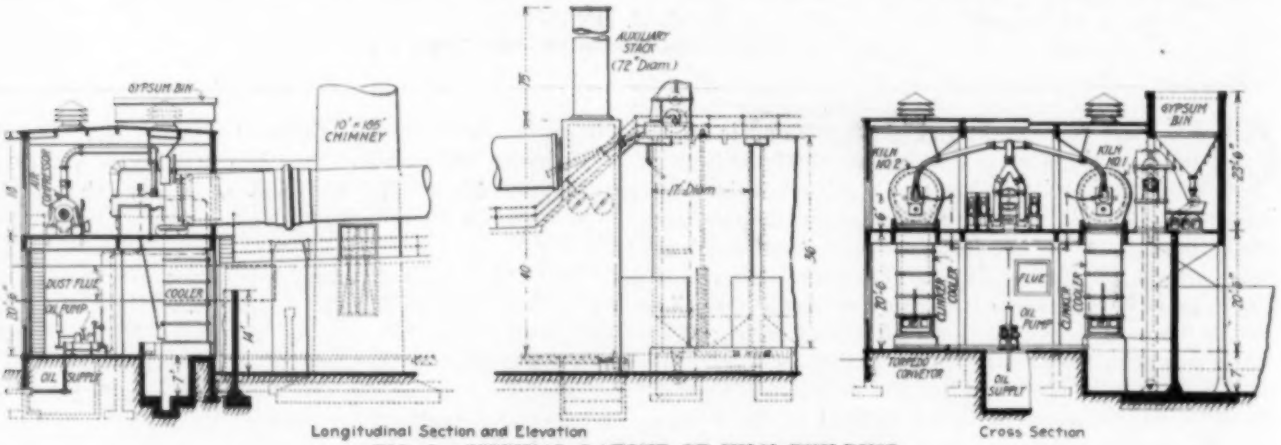


FIG. 2.—GENERAL LAYOUT OF KILN BUILDING

While the dust chamber potash was evidently a bird in hand, an economical method of catching the unknown quantities of richest and finest dust emitted from the stack urgently demanded attention. A somewhat standardized and familiar solution of this problem is the use of the Cottrell system of electrostatic precipitation. Many of these installations, however, while catching all of the coarser dust, pass a considerable percentage of impalpable material, which unfortunately is most desirable, since it has the largest potassium content of any fraction. Again, owing to certain business considerations we were unable to obtain a satisfactory license to use the Cottrell process, and so we cast about for an alternative and hit upon the present scheme.

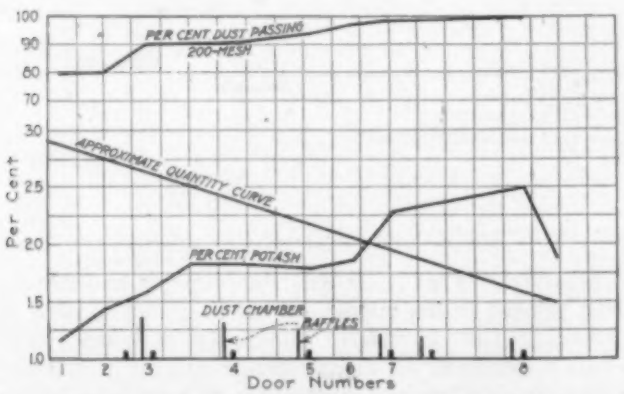


FIG. 3.—RECOVERY OF K_2O IN DUST CHAMBER

Precipitation by Water and Water Vapor

Briefly, we planned on spraying the hot gases with sufficient water to wash out the particles in suspension, filtering the spray water from its insoluble sludge, and evaporating the filtrate. For the latter operation every consideration pointed to the desirability of using the flue gases as a source of heat. Whether to build the evaporator ahead of the spray chamber or beyond it was given careful consideration: in case hot furnace gases above 100 deg. C. were used an evaporator at atmospheric pressure could be utilized, thus simplifying and lightening the evaporator construction and obviating the need of vacuum pump and condensers. However, if these gases were sprayed, they would have required large radiating surfaces or else a prodigious amount of vaporized water would have been lost in the hot saturated stack gases. Furthermore it was early found that the largest excess of water dripping through dusty gases failed to wet and precipitate satisfactory amounts of the solids rich in potassium. This is in line with the well-known difficulty—almost amounting to an impossibility—of satisfactorily and completely wetting finely divided particles such as flowered sulphur and many other condensates. However, if saturated dusty gases are cooled so that the water vapor contained will condense, the nascent globules of mist form about the dust particles as nuclei. Now if the resulting fog can coalesce and be collected in some way the result will be a dust-free gas saturated with vapor at the temperature of escape, and a sludge containing soluble salts in solution and insoluble particles in suspension.

Evidently, then, it was not only necessary to thoroughly humidify the hot gases, but even more necessary to cool the gases to the least possible temperature before their discharge. The radiating heat from these cooling gases could naturally be utilized to evaporate the considerable quantities of weak solutions produced — every pound of water condensed would give up sufficient heat to evaporate another pound of water.

From these and like considerations a condenser-evaporator shown in cross-section in Fig. 1 and discussed in detail later, was placed after the spray chamber. In operation the water which condenses inside the tubes evaporates the same amount outside the tubes; the cool-

ing furnace gases give up heat to evaporate excess additions, and the gases escape at a low temperature with their waste heat largely abstracted and utilized.

Chemistry of Process

The potassium and sodium in the feldspar and other minerals contained in the cement rock mixture are volatilized as oxides to a certain extent by the intense heat in the clinkering zone, and probably react with sulphuric acid anhydride to form their sulphates. The sulphur in the fuel oxidizes as follows:

$$S + O_2 = SO_2$$

$$2SO_2 + O_2 = 2SO_3 \text{ (probably by contact)}$$

$$SO_3 + K_2O = K_2SO_4$$

After these reactions take place near the focus, if the sulphates pass on into a reducing atmosphere sulphides will be formed, according to the typical reaction:

$$K_2SO_4 + 4CO = K_2S + 4CO_2$$

Thiosulphates and carbonates are also formed in the hot, humid gases according to one or more of the following reactions:

$$K_2S + SO_2 = K_2S_2O_2$$

$$2K_2S + 2O_2 + CO_2 = K_2S_2O_3 + K_2CO_3$$

$$K_2S + H_2O + CO_2 = K_2CO_3 + H_2S$$

On reaching the spray chamber, then, the gases bear particles of fume consisting in part of potassium and sodium sulphides, sulphates, and thiosulphates, together with some complex polysulphides. The water which washes these particles out of the gas also absorbs carbon dioxide. Some bicarbonates will form in the condensate in this manner:

$$K_2CO_3 + CO_2 + H_2O = 2KHCO_3$$

These bicarbonates rapidly oxidize any remaining sulphides as follows:

$$K_2S + 2KHCO_3 = 2K_2CO_3 + H_2S$$

The hydrogen sulphide rapidly hydrolizes to water and sulphur, which latter reacts with any sulphite, which may rarely be present

$$2Na_2SO_3 + 2S = 2Na_2S_2O_3$$

A considerable quantity of this sulphur also condenses on the sides of the stack through which the spent, cool kiln gases eventually escape.

Somewhat in the above manner the mixed spray chamber sludge and condensate contains in solution principally the following ions:

$$Na+,\ K+,\ CO_3=,\ S_2O_3=\text{ and }SO_4=$$

Potassium sulphate can readily be separated from sodium thiosulphate; the former crystallizes from hot solutions, while the latter comes down on cooling; therefore it is desirable to remove the $CO_3^=$ and furnish $SO_4^=$ in its stead. This is done at present by drawing the solutons through a bed of gypsum whch effects the interchange as follows:

$$CaSO_4 + K_2CO_3 = CaCO_3 + K_2SO_4,$$

the calcium carbonate remaining behind as an insoluble. Calcium sulphate must be used with circumspection here, however, since gypsum is soluble in thiosulphate, and the whole evaporating system may become overloaded with gypsum, effectually interrupting operations. This may readily be prevented by making sure that a little $CO_3^=$ remains in the solution after gypsum treatment. The test is easily made for the carbonate ion with normal HCl using methyl orange as an indicator. By this titration to a faint pink color the sulphur of the thiosulphate will not separate out. The solution is then titrated with 0.1 N iodine for the thiosulphanion. An increased acidity rarely occurs by the oxidation of the iodine by small amounts of sulphite present.

The liquor now contains $Na+$, $K+$, $S_2O_3=$, and $SO_4^=$. Since there is not enough sulphate anion to unite with all of the potassium present, a part of the potassium would crystallize as thiosulphate if the solution were evaporated. As an actual fact, in the presence of sodium ions the double salt $K_2S_2O_3:Na_2S_2O_3:\frac{1}{2}$ to $1\frac{1}{2}H_2O$ is formed, which together with K_2SO_4 represents the salt collected from an evaporation in our crystallizing evaporator. Since the amount of sodium present in the weak sodium ions the double salt $K_2S_2O_3:Na_2S_2O_3:\frac{1}{2}$ to $1\frac{1}{2}H_2O$ vents its concentration. Whenever the Na^+ reaches a saturation point, a small drop in temperature will freeze the crystallizer solid with the sudden precipitation of $Na_2S_2O_3\cdot5H_2O$. In actual practice the salts as they come from the crystallizer-evaporator are dried and heated to remove a part of the sulphur of the thiosulphates. This gives a product of about 90 per cent K_2SO_4, which is entirely acceptable to our customers.

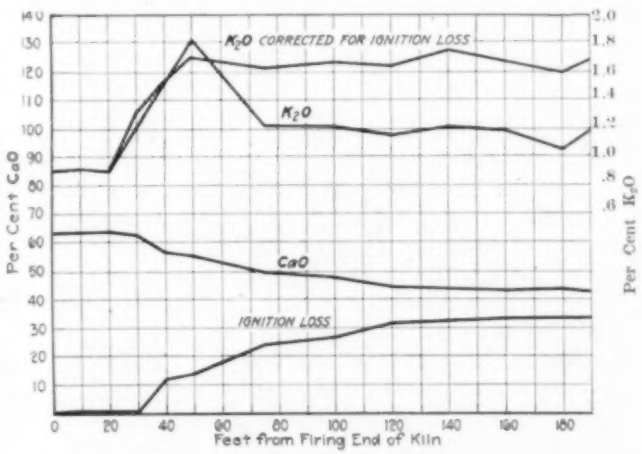


FIG. 4.—PROGRESSIVE COMPOSITION CHART OF WET PROCESS KILN

If it is desirable to prevent the formation of the double thiosulphates, enough Na_2SO_4 may be added to the solutions to furnish the necessary amount of $SO_4^=$ for the K^+ present in excess. This salt also furnishes the requisite amount of Na^+ for the $S_2O_3=$. Pure potassium sulphate will then crystallize from boiling solutions up to the point of saturation of the sodium salt. Now if these hot solutions are drained into a crystallizing tank and allowed to cool, $Na_2S_2O_3\cdot5H_2O$ will crystallize, while the potassium sulphate remaining in the mother liquor can be returned to the primary evaporator.

Burning Conditions In the Kiln

As was stated at the beginning of the discussion of the chemistry of the process, in order to produce the thiosulphates and carbonates in the final liquors it is necessary to have a slightly reducing condition in the kiln. This has been brought about, apparently, by the improper atomization of the oil fuel. While this condition has operated largely in favor of easy manipulation of the potash liquors and the final purification of the potash salts it has not helped in volatilizing the potash from the raw materials in the kiln itself. So far it has

been impossible to volatilize more than about 45 per cent of the potash content, as is shown by the composition chart given in Fig. 4. If the burning conditions could be changed so as to produce the short, intense flame necessary for the most efficient production of cement clinker with the minimum amount of fuel, it would undoubtedly increase the volatilization of the potash considerably at the same time. To do this would destroy the reducing atmosphere necessary for the formation of the thiosulphates and carbonates, and would make the handling of the liquors more difficult and the separation of the potassium and sodium salts practically impossible. However, a method is now under consideration that will make it possible to take advantage of both conditions, giving a maximum cement production and potash volatilization together with our present ease in handling the liquors and purifying the final salts.

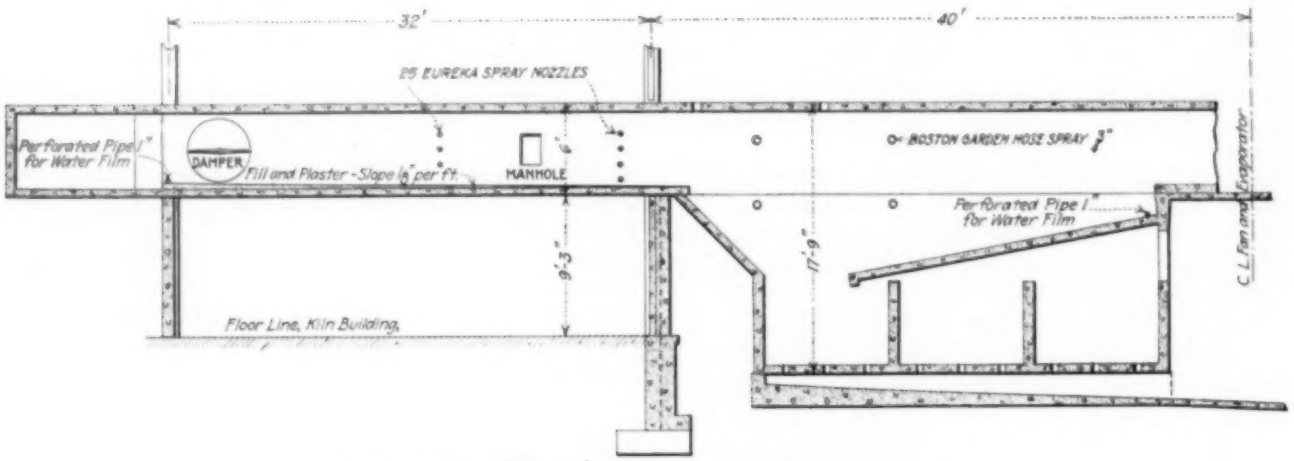


FIG. 5.—LONGITUDINAL SECTION OF SPRAY CHAMBER

The addition of salt (NaCl) to the kiln feed would undoubtedly increase the volatilization of the potash. On the other hand, this would decrease the purity of the final product. The introduction of chlorides is not altogether desirable for other reasons as well. Fluorspar added to the raw material would achieve the same result without the addition of new salts to the final product. In an installation described under "a permanent installation," where all the isoluble dust is returned to the kiln, the CaF_2 would be reclaimed and used over and over again.

The raw materials as they come from the quarry are somewhat deficient in SiO_2. This is corrected by adding a small amount of granitic rock found along the right of way. This material analyzes about 5 per cent K_2O, and its use increases the potash content of the raw materials entering the kiln from about 1 per cent to an average of 1.2 per cent. If we had a pure limestone to use it would be possible to increase the potash content by the addition of the feldspar available to more than 2 per cent.

Operation of Experimental Plant

The drawing, Fig. 1, indicates the main features of the experimental plant. An opening was cut in the end of the dust chamber underneath the kiln and a concrete dust flue built under the firing floor. Just outside the kiln building is located the spray chamber shown in detail in Fig. 5, which is merely a section of the flue about 30 ft. long equipped with fifty Demeral spray nozzles in top and sides. The three tanks in the V-shaped bottom are provided with valves in the bottom, the first of the tanks receiving the condensate from the condenser-evaporator set, as noted later. The collected sludge is drawn at regular intervals into a trough leading to an elevator driven from the fan shaft and from which it is delivered to a small Oliver filter. The filtrate, together with the overflow from the condensate-receivers goes to a concrete storage tank 10 ft. by 10 ft. by 6 ft. deep, holding 4500 gallons.

In passing it may be noted that the atmosphere above the settling tanks as well as the sludge water is strongly charged with ammonia. It is probable that this ammonia comes from the combined nitrogen in the fuel, and its collection is one of the problems for future consideration.

The gases leaving the kiln average 700 deg. F. in temperature. They seldom contain oxygen, and therefore indicate no excess air; in spite of the known reducing condition in the kiln atmosphere they seldom contain carbon monoxide. Table I gives the computation of the kiln-stack conditions, allowing for no infiltration of air, from which it may be computed that at standard conditions of temperature and pressure the gases amount to 15,000 cubic feet per minute and analyze approximately:

	Per Cent
CO_2	15.8
N_2	46.7
H_2O	36.5

On passing through the dust chamber the temperature drops to about 450 deg. F., due to radiation and dilution with the outside air which is drawn through the cracks and expansion joints in the concrete walls. This dilution will average under general conditions approximately 50 per cent.

A considerable excess of water is used in the spray chamber, about 50 gallons per minute being drawn off in addition to that vaporized by the hot gases. These finally enter the condenser-evaporator tubes at 250 deg. F., 79.5 pounds of water having been evaporated to cool the gases to this temperature while passing through the spray chamber.

On entering the tubes of the condenser its volume at standard conditions of temperature and pressure is

24,000 cu.ft. per minute, and its composition may be figured to be:

	Per Cent
O_2	6.4
CO_2	9.8
N_2	54.4
H_2O	29.3

During the passage through the condenser tubes the temperature of the wet gases further falls to 140 deg. F., and is discharged holding only 6.37 pounds of true water vapor per thousand cubit feet of gas, plus some entrapped mist which failed to collect in the condenser tubes. This will amount to between 60 and 75 pounds per minute. The evaporator itself operates at 24 inches vacuum (3 inches absolute pressure at the elevation of Victorville) and a temperature of 115 deg. F.

During the passage through the condenser tubes the gasses have thus radiated the following amounts of heat per minute in cooling from 250 to 140 deg. F.:

	B.t.u.	B.t.u.
O_2 ..... 1,560 cu.ft. at 2.28 =		3,556
N_2 ..... 13,144 cu.ft. at 2.28 =		28,968
CO_2 ..... 2,380 cu.ft. at 2.87 =		6,830
H_2O..359.5 pounds entering at 250 deg. F. contains	416,021	
114.0 pounds leaving at 140 deg. F. contains	127,861	
245.5 pounds condenser losses.....		288,160
Total radiation in condenser..		327,514

Supposing that 90 per cent of this heat is transferred through the condenser tubes and is utilized in evaporating water at 3 inches absolute and 115 deg. F., 283 pounds of water would be evaporated per minute. (Since one pound of water at 100 deg. F., the temperature of the liquor entering the evaporator, contains 68 B.t.u. and the total heat of water vapor at 115 deg. F., the temperature of evaporation, is 110.2 B.t.u., the difference of 1042.2 B.t.u. is the heat absorbed in evaporating one pound of water. Therefore, $0.90 \times 327{,}514 \div 1042.2 = 283$ pounds of water evaporated per minute.)

The water balance for one minute may then be tabulated thus:

	Pounds	Pounds
Vapor from slurry and combustion in cement kiln....	280.0	
Vapor from spray coolers.....	79.5	
Total water entering condensers.....		359.5
Less vapor uncondensed.....	114	
escaping mist.....	70	
		184.0
Balance condensed		175.5
Amount evaporated		283.0
Excess over condensate.....		107.5

This excess is made up by spray-tank sludge, wash water and reagent solutions.

It is apparent that considerable latitude for adjustment is possible in the evaporation system. For instance, if the quantity of weak liquor in the storage tank builds up, it is only necessary to reduce the amount of water entering the spray chamber. This not only produces a smaller amount of sludge water to be evaporated, but passes a hotter gas, which, while it transfers very nearly the same amount of heat through the tubes of the condenser-evaporator in cooling to the proper temperature —140 deg. F.—forms less condensate which must later be evaporated. Or the condensate may be put back with the spray water, since the water line supplying the spray chamber is connected to the liquor-storage, cooling pond and the regular plant water supply.

Condenser-Evaporator

As is shown in the drawing, Fig. 6, the condenser-evaporator is of reinforced concrete construction. The flue sheets are $\frac{3}{8}$ in. steel plates tied to the reinforcing steel at the edges. The concrete walls are heavily reinforced to withstand the outer pressure due to vacuum as well as the inner pressure of the liquor. A few settlement cracks have occurred, but these have been easily sealed by an application of asphaltic paint to the outside of the walls. A vacuum of 23 to 24 in. at an elevation of 2700 ft. is fairly good evidence that the materials of construction are not lacking in many essentials. The necessary clean-out doors have been placed at each pass, as shown in the detailed drawing. The accumulated sludge is easily removed at intervals of 24 hours with a swab provided with a water spray. Clean-

TABLE I—KILN STACK CONDITIONS AS CALCULATED FROM AVERAGE PERFORMANCE SHEETS

Average conditions employed in calculations:

Kiln feed = 38.5 per cent water.
Dried kiln feed = 36 per cent loss, assumed to be CO_2.
960 lb. of wet feed will, therefore, produce in the process of burning 370 lb. of water, 210 lb. of carbon dioxide, and 380 lb. of clinker, or one barrel. Assume perfect combustion.
Fuel necessary per barrel = 10.4 gallons crude oil = 84 pounds.
Ultimate analysis of oil:

	Per Cent.
Carbon	86.06
Hydrogen	11.45
Sulphur	.87
Nitrogen	1.00
Moisture	.50

Amount of oxygen required to burn one pound of this oil:

0.8606 × 32 ÷ 12 = 2.2949 lb. oxygen to burn the carbon.
0.1145 × 32 ÷ 4 = .9160 lb. oxygen to burn the hydrogen.
0.0087 × 32 ÷ 32 = .0087 lb. oxygen to burn the sulphur.

Or it takes 3.2196 lb. oxygen to burn one pound of this oil.

Assuming dry air to contain 23.1 per cent oxygen by weight, then it will require as much air to furnish this amount of oxygen as 3.2196 ÷ 23.1 = 13.937 lb. of air. This amount of air will introduce (13.937 — 3.2196) = 10.7174 lb. of nitrogen.

Then, total air necessary to burn one barrel of clinker = 84 × 13.937 = 1170.7 lb. of air.

Products of Combustion

One lb. of oil would produce:

0.8606 lb. of carbon + 2.2949 lb. of oxygen	=	3.1555 lb. of carbon dioxide.
0.1145 lb. of hydrogen + .9160 lb. of oxygen	=	1.0305 lb. water.
0.0087 lb. of sulphur + .0087 lb. of oxygen	=	.0174 lb. sulphur dioxide.
Nitrogen in the oil	=	.0100 lb. nitrogen.
Nitrogen with the oxygen from air	=	10.7174 lb. nitrogen.
Moisture in oil	=	.0050 lb. water.
Total products of combustion		14.9348 lb. per pound of oil.

84 × 14.9348 = 1254 lb. per barrel of clinker produced.

In burning or producing one barrel of clinker from 960 lb. wet kiln feed and 84 lb. of oil the stack gases would contain:

84 × 3.1555 = 265.06 lb. CO_2 due to combustion.		
210.00 lb. CO_2 due to dissociation.		
	475.06 lb. of CO_2	
84 × 1.0355 = 86.98 lb. of H_2O due to combustion.		
370.00 lb. of H_2O due to evaporation.		
456.98 lb.	456.98 lb. of H_2O	
84 × 0.0174 = 1.46 lb. SO_2 due to combustion.	1.46 lb. of SO_2	
84 × 10.8174 = 908.66 lb. N_2 with air and oil.	908.66 lb. of N_2	
Total stack gases per barrel of clinker produced,	1,842.16 lb.	

Average temperature of stack gases = 460 deg. F. Barometer = 27.2 in.
Relative volumes at standard conditions:

		Cu.Ft.	Per Cent	(Without water) Per Cent
Volume CO_2	= 475 × 16 ÷ 1.98 =	3,838	= 15.7	= 25
Volume H_2O	= 456.9 × 16 ÷ 0.81 =	9,025	= 36.9	
Volume SO_2	= 1.46 × 16 ÷ 2.88 =	8	= 0.0	
Volume N_2	= 908.6 × 16 ÷ 1.26 =	11,537	= 47.2	= 75
Total volume		24,498	99.8	100

Volume at 460 deg. F. and 27.2 in. barometric pressure =

$$24{,}498 \times \frac{458 + 460}{490} \times \frac{29.93}{27.2} = 50{,}500 \text{ cu.ft.}$$

Density of stack gases compared with dry air =
1,842 × 16 ÷ 1.293 = 22,793 cu.ft. 22,793 ÷ 24,498 = 0.93 = density.

ing requires about an hour and is easily done, since there are no hard incrustations to remove.

The set contains 1052 tubes, 3½ in. in diameter and 14 ft. long, divided into three passes, as shown. The only tubes that could be had at the time of building were of very poor quality, which necessitated patching and welding a great many seams. However, we have not experienced the least trouble since placing them in the flue sheets.

In order to provide the extra surface for collecting the condensed water, the tubes are divided into three passes. That portion of the condensate which does not coalesce in the tubes is carried out as entrained mist, as has already been mentioned during the discussion of the water balance of the system. The collected condensate is drained through a water seal to the first

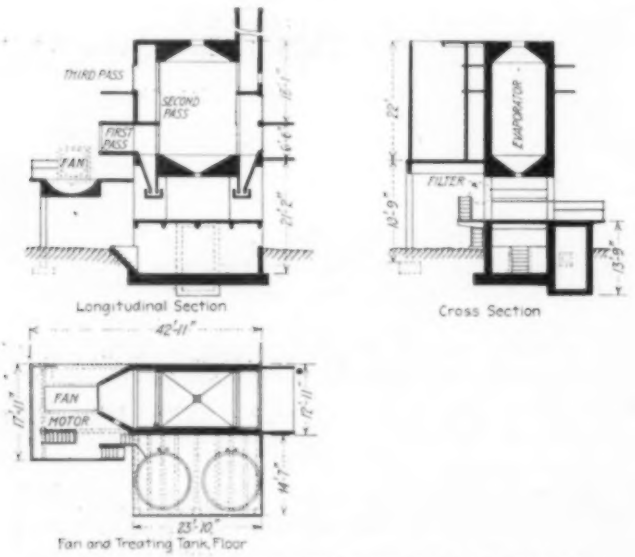


FIG. 6.—DETAILS OF CONDENSER-EVAPORATOR

settling tank provided in the spray chamber (Fig. 5). The combined liquors after passing through the three settling tanks run by gravity to the 4500-gallon tank mentioned in the discussion of the spray chamber, and will average from 2 to 2.5 per cent potassium sulphate.

The liquors surrounding the tubes on the inside of the condenser-evaporator are vaporized by means of the condensation taking place within the tubes. In order to provide the necessary temperature gradient, a vacuum is maintained in the evaporator of from 23 to 24 in. mercury, or an absolute pressure of from 3 to 4 in. Consequently the liquor in the evaporator is vaporized at 115 to 120 deg. F., while condensation on the other side of the tubes is taking place at approximately 208 deg. F. Obviously, the greater vacuum inside the evaporator the greater the temperature drop across the tube, and the lower the temperature of the exit gases.

Vacuum is provided by means of a condenser of the rotating jet type, known as the "Rees-Roturbo" condenser, supplied by the Manistee Iron Works, of Manistee, Mich. This condenser is connected with the evaporator by welded pipe as shown in Fig. 1. The condensing water and condensates flow by gravity to a cooling pond, 50 ft. by 200 ft. by 3.5 ft. deep, where it is cooled by suitable sprays. Cooled water is returned to a well shown directly under the condenser (Fig. 1) and is drawn back to the rotating jets for re-use. The necessary screens are provided to prevent refuse from entering the machinery.

The Roturbo condenser is direct connected to a 75-hp. induction motor, which also drives the necessary pumps, sludge elevator, and an Oliver continuous filter with its vacuum pump.

The draft fan is belt-driven by a 30-hp. induction motor. The stack between the kilns is provided with a water-sealed damper, while the flue leading to the fan is provided with a swinging damper. Whenever, it is desired to close down the potash treater, the damper in the stack is raised and that in the flue closed so that the operation of the kiln is not interrupted.

Sand Filter and Gypsum Treater

Condensate and spray chamber overflow collected in the 4500-gallon tank contains mud and unconsumed carbon in suspension besides the substances mentioned and discussed under "The Chemistry of the Process." The solids are removed by a sand filter placed in the bottom of one of the gypsum bins at the end of the clinker storage. Whenever the liquors need a treatment for the removal of the $CO_3^=$ and the addition of the $SO_4^=$ ions, crushed gypsum rock is spread over this sand filter and the sludge and precipitated calcium carbonate are removed simultaneously.

A filtered liquor is now ready for the condenser-evaporator and is run by gravity to one of the crystallizing tanks shown at the right of Fig. 1. These tanks are 15 ft. by 50 ft. by 4 ft. deep, and hold 25,000 gallons. They were originally built for crystallizing the salts by cooling the saturated brines, but since installing the crystallizing evaporator shown in outline in Fig. 1, and described later, these tanks are being used for storage purposes. As necessary, the weak liquor is pumped into the cylindrical tanks alongside the condenser-evaporator (Fig. 6) and from there flows into the evaporator as needed.

Kiln Dust Chamber

Fine material accumulating in the dust chamber beneath the kiln is at present drawn out through side doors and conveyed to a mixing chamber near the slurry tanks at the upper end of the kiln. This dust is made into a thin slurry with water, and when thoroughly agitated is elevated to an Oliver filter. The filtrate averages about 2 per cent potassium sulphate, and is pumped to the sand filter.

The original intention was to return the filter cake to the slurry tanks, but for some reason not yet determined a very little of this cake will thicken a whole tank of slurry so that it will not run through the outlet pipes provided at the bottom of the tanks. Even if the cake is put into the bottom boot of the elevator, the slurry in the buckets will become so thick and pasty that it will not drop out at the top. However, if the cake is directly introduced into the kiln at about the same rate as it is collected it gives very little trouble, while if too much is fed into the kiln it becomes very dusty and hard to regulate.

A crystallizing evaporator was an after consideration. Originally the liquors were concentrated in the evaporator-condenser to 24 to 26 deg. Bé. and then drained into the crystallizing tanks to cool and crystallize. After

a certain number of days the mother liquor was returned to the evaporator.

This method was too slow and cumbersome. The salts were very wet, the drying was tedious, and as the alkalinity increased in the liquor the amount of solids held in solution increased very rapidly. Thus the difference of solubility in cold and hot solutions became so small that we abandoned this method and installed a crystallizing evaporator.

The plan of using the crystallizing evaporator as a second effect to the condenser evaporator was considered. The hot gases in the dust chamber were also a possible source of heat, but it was finally decided to use steam from the boiler in the kiln-room. Of course this is not an economical way of performing the operation, but it was considered best at the time.

The evaporator was designed by Mr. Gilbert, and built at one of the sheet metal shops in Los Angeles. There is nothing about it of unusual design, it being simply a steel tank with a conical bottom closed by a 10-in. gate valve which in turn is bolted to a closed tank beneath, as shown in outline in Fig. 1. This lower chamber is provided with a clean-out door, grate and drain-pipe. The steam basket is built of sheet metal, with ten 3-in. vertical flues. The basket is placed in the upper part of the conical portion of the upper tank with the necessary steam pipe and drain leading through the sides of the evaporator, and the condensed water is returned to the boiler through a trap.

At present the liquors are concentrated in the condenser-evaporator to from 15 to 18 deg. Bé. and then pumped into the crystallizing evaporator. As the salts drop out of solution they settle into the lower or crystallizing compartment. Every 24 hours the gate valve separating the two is closed and the liquor pumped from the lower to the upper compartment. After the salts are thoroughly drained the door is opened, the salts removed, dried and are then ready for shipment.

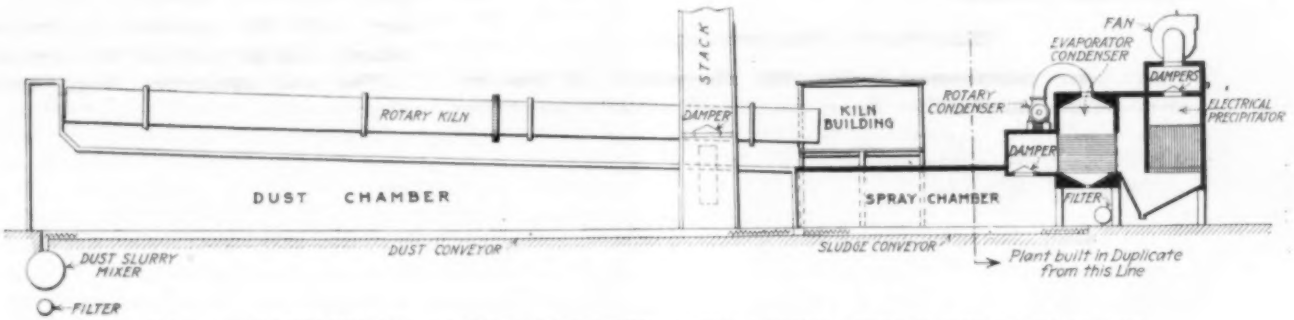


FIG. 7.—DIAGRAMMATIC LAYOUT, COMBINED INSTALLATION, POTASH RECOVERY PLANT

Permanent Installation

Since the experimental installation is something of a pioneer in this method of potash recovery, it would be nothing strange if some troubles had developed that had not been fully anticipated. These different situations have been met as they occurred, and by their actual or evident solution a design of a permanent plant has been evolved. Fig. 7 is a diagrammatic drawing showing most of the essential changes that would be incorporated.

The dust chamber would be designed so as to be easily cleaned by means of screw conveyors running underneath. It should be mentioned here that there is no particular necessity of having a dust chamber as large as the one here shown. The chamber at present under the kiln was constructed at the time of building the cement plant, while of course the spray chamber was added later. With a shorter dust chamber it would be possible to do all the leaching and filtering at the potash recovery plant and to return the combined filter cake to the kiln.

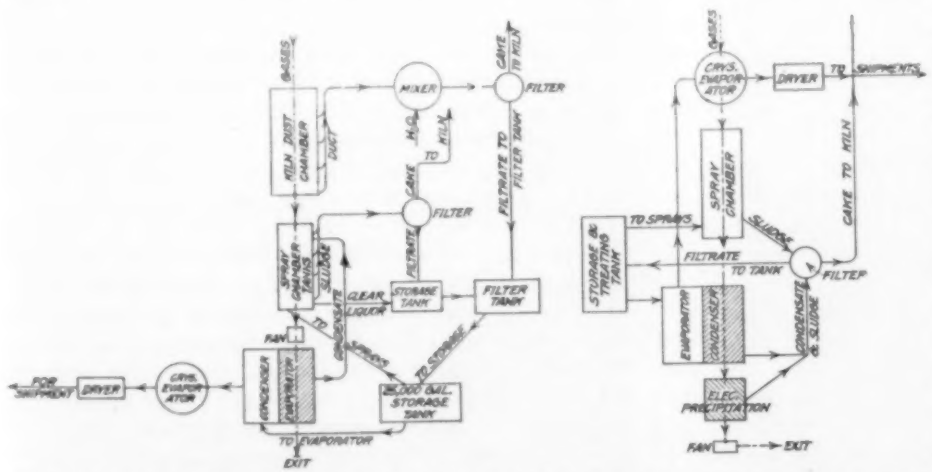


CHART I.—FLOW SHEETS OF PRESENT AND PROPOSED PERMANENT INSTALLATIONS

The spray chamber should be large enough to allow for considerable expansion of the gases and for deposition of the dust consequent to a low velocity. The spray nozzles should be capable of giving the finest droplets possible. To avoid hand-cleaning in the spray chamber, it would be advisable to remove the sludge with a screw conveyor direct to the filter. If possible, all liquors should be filtered before being allowed to enter a pump since the incrustation and plugging of pumps has been a cause of many delays and shut downs.

A fan should be placed at the final outlet for the gases. The gases should then be free from all dust, cool and small in volume.

The condenser-evaporator unit would have but one pass. It would be built in duplicate by being divided by a center partition wall with the necessary dampers to permit one side being cleaned while the other side remained in operation. This would make continuous operation possible.

Electrical Precipitation

As was mentioned under the discussion of the experimental plant, the three passes of condensing tubes are used for condensing the vapor and coalescing the precipitated mists so as to remove the water with its dissolved potash from the system. Also it was stated that possibly 60 to 75 pounds of precipitated mist per minute are carried out as an entrainment loss.

In the experimental work on these exit gases it was found that the potash salt carried in solution in the water was not all that was leaving the treater, but at times there were large amounts of potash fume escaping that had apparently resisted the wetting process. This was a great disappointment as it was supposed that if enough water were present during the process of condensation, every particle of dust and potash fume would act as nuclei, and in order to collect all the potash it was only necessary to provide means for collecting all the condensed water particles. If this were the case the small amount carried out by entrainment would not be serious; that is, it would be possible to reduce the loss to possibly 10 per cent, thus giving a 90 per cent recovery.

There are numerous ways of collecting the residual mist, such as condensers, gas scrubbers, coke towers, excelsior beds etc., but the discovery that considerable potash fume had resisted the process of wetting necessitated a different procedure altogether. The application of electrical precipitation to these gases was suggested through the experience of Mr. P. S. Taylor[1] at Riverside, where he was closely connected with the development of the Cottrell electrical precipitation process for the precipitation of the dry dust.

The matter was accordingly taken up with the Western Precipitation Co. of Los Angeles, and they very kindly loaned the necessary equipment and helped conduct a series of experiments on the electrical precipitation of the exit gases.

Without going into a lengthy discussion of these experiments, it may briefly be stated that it was found possible to remove practically all the potash fume contained in the gases, and that at times the water collected in the precipitation tubes carried very little more potash than the regular condensates of the condenser-evaporator, while at other times this precipitated liquor would carry eight to ten times as much potash. This showed that the potash fume in the one case had been efficiently wetted and removed by the process of condensation, while in the other case the potash fume had apparently resisted wetting.

It has been suggested that possibly the reducing condition of the kiln or the presence of the unconsumed fuel might be the cause of this condition. Undoubtedly it is a surface phenomenon, and unfortunately it has persisted in spite of the efforts made to correct it. Whether the presence of dry fume in considerable percentages is or is not the usual condition is a matter for further investigation. It seems doubtful, however, that it can be entirely eliminated. In any case, the use of the Cottrell process for the final scrubbing eliminates the possibility of the escape of this fume, and does away with the necessity of the numerous passes necessary with the present condenser-evaporator system to collect a large part of the already condensed mist.

The cool, saturated, foggy gases passing through the precipitation tubes seem to give the ideal conditions for complete electrical precipitation, the voltage necessary being comparatively low and the rate of flow of the gases relatively high. This calls for the minimum number of pipes, electrical connections and other accessories. By having the fan at the exit, the insulation of the electrical connections is greatly simplified.

In the permanent installation these electrical precipitation tubes would be made of cement tile, since their surface would be constantly wetted and conducting. Thus the whole installation would be of concrete construction with the exception of the condenser-evaporator tubes and flue sheets. This is an important consideration at this particular time.

Handling of Liquors

The crystallizing evaporator would probably be placed in the dust flue in front of the spray chamber. The steam from the evaporator could be returned to the flue so that practically all of the heat would be conserved.

Instead of using gypsum for removing the $CO_3^=$ and increasing the $SO_4^=$ in the filtered liquor, it would be possible to substitute strontium sulphate or celestite. The precipitated strontium carbonate could be dissolved in nitric acid, the solution concentrated and the anhydrous strontium nitrate precipitated from the boiling liquor.

As will be seen from the diagrammatic sketch, Fig. 7, this combination process is very simple and every provision has been made for continuous operation. The coarser particles of dust will be deposited in the spray chamber and removed directly to the filter by a conveyor. Finer dust will lodge in the condenser tubes, and that portion which is not washed out by the condensates can be easily removed by shutting down but one-half of the plant. The cool gases going to the electrical precipitator are thoroughly saturated with water vapor and will carry in suspension a large amount of condensed water in the form of mist. This mist will be precipitated on the sides of the tubes and form a water film for the collection of the dry fumes which will also be caught. The gases passing through the tubes being already saturated and in the course of cooling are unable to absorb more water vapor, so there is no possibility of losing the water film by evaporation. Since there can be no concentration without evaporation, there can be no incrustation of salt in the tubes.

It will be noted in going over the amounts of water collected and ejected from the treater that the maximum amount of potash salts in the final liquor is very small —not exceeding 2.5 to 3 per cent K_2SO_4. This of course necessitates a cheap method of evaporation, which is provided by the condenser-evaporator.

The precipitated liquors from the condenser and the electrical treater, carrying the soluble salts in solution and the fine dust in suspension, will be drained through

[1] "Electrical Precipitation of Cement Dust," *Journal of Electricity, Power and Gas.* Vol. 32, pp. 219-223, March, 1914.

a water seal to the same filter as is used for filtering the sludge from the spray chamber. This simplifies the pumping and piping arrangements and brings together all of the insoluble portion of the collected sludge into one filter cake which can be returned to the kiln. The recombined potash and trapped solution will be contained in this cake, both of which will be quite easily volatilized in the kiln. Of course the insoluble potash would not volatilize so easily, but whatever the treatment necessary for the insoluble potash contained in the sludge, the filter cake presents a convenient form for further treatment.

Conclusion and Acknowledgments

Thus, from the experience gained in operating the present experimental plant there has been evolved a simple and comparatively inexpensive installation for the complete recovery of the soluble potash salts and dust from the kiln stack gases. The weak liquors will be evaporated and the potash recovered in a purified form and the dust returned to the kiln. The operating cost, according to the present installation, would be nearly covered by the value of the returned dust, making the present actual cost of collecting the potash a very small item. In the future even this will undoubtedly be more than offset by the better operating conditions of the whole plant, as the conditions necessary for maximum potash production call for the maximum cement production and the minimum operating expense.

In closing this long, though somewhat incomplete, discussion of this system of potash recovery, it should be mentioned that the work of designing, constructing and operating the plant, as well as the experimentation, has been carried on largely by the combined efforts of L. D. Gilbert, P. S. Taylor, L. E. Elder, and the writer. Mr. C. Leonardt, the president of the Southwestern Portland Cement Co., has been more than generous in providing the necessary funds, and it is largely his great interest and enthusiasm that has made possible the recovery plant and the experience above recorded.

Victorville, Cal.

The Brown Process for Cement and Potash

WE HAVE received from Mr. Chester Huntington a paper on the process for making cement and potash from feldspar and limestone invented by Mr. H. E. Brown and covered under U. S. patents Nos. 1,123,841, 1,123,864 and 1,124,238. Owing to lack of space we can give but an abstract of the original article and the improvements claimed for it.

Feldspar and limestone are broken in a jaw crusher, mixed, and fed with coke or hard coal into a blast furnace and fused. The potash passes off with the furnace gases and is carried to a dust-collecting apparatus where most of the potash is precipitated in the form of carbonate, oxide and some sulphate.

The molten mass is tapped and run upon a granulating and cooling device where it is sprayed with a solution of magnesium sulphate. The granulated material is dried by the heat of the clinker and is carried to the bins of the cement grinding apparatus.

It is claimed that the cement so produced is of a superior quality due to the excess of silica in colloidal form and to the thorough fusion which eliminates free lime. This avoids continued chemical action after the cement is set and renders it especially adapted to the construction of sea walls, docks and concrete ships. It may be made free from iron. Tensile strength tests show a higher average than Portland cement. Over 75 per cent of the total potash content may be recovered from the gases. That is, the inventor claims to liberate over 85 per cent of the potash in the change and that a precipitation of 90 per cent may be expected in the recovery apparatus. In experimental practice so far with high-potash feldspar a dust containing over 55 per cent potash was found in the collector.

A further claim is that the cost of a complete potash and cement installation will not exceed 70 per cent of the cost of a cement plant of the same capacity owing to the elimination of preliminary grinding of rock and coal and the consequent reduction of power requirements. The blast furnace should cost less than rotary kilns and take up less room. The housing requirements including the dust collector should not exceed those of a cement mill built on current lines. The grinding of the clinker is by standard methods.

The operating costs should be less than those of a Portland mill, owing to the avoidance of preliminary grinding and because gases from the top of a closed blast furnace may be more economically utilized than the gases from rotary kilns. It is held to be within the possibilities that a well designed plant can be made to supply all its power requirements from waste gases. In short it is claimed that by this process a superior cement is produced at a lower capital outlay and at a less cost per barrel than Portland cement, even if all dust-collecting costs are charged against the cement, and that it makes a vast quantity of potash available as a by-product. In plants that are favorably located it is held that 15 to 18 lb. of potash may be produced to each barrel of cement.

Literature of the Potash Industry 1912-1917

By F. W. Bruckmiller

THE following general review of the potash literature is an attempt to collect in concentrated form the essential statements of the more important articles published from 1912 to 1917. No attempt is made to make an exhaustive report, but it is believed that the articles generally available have been listed. The statements under each reference are just as the writer made them:

General

Cameron (1) points out that as a conservation scheme kelp is of more importance than saw mill or sugar house wastes. The conservative estimated production is 1,000,000 tons of KCl per year from kelp; 5200 tons K_2O from sawdust; no figures available on sugar wastes. Silicate rocks and brines are not factors in the industry as yet.

McDowell (4) contends that if an American industry is to be built up, "someone must spend money," and two industries that can well afford to do so are the cement and sugar industries. Before brine development can proceed there must be a positive control of acreage.

Cresswell (5) reviews briefly the processes from all sources but gives no data. Numerous references as well as abstracts of articles on working feldspars and silicate rocks are included in the paper.

Dolbear (6) summarizes the efforts in the United States under four heads: (1) From Searles Lake; (2) from "vinasse"; (3) from kelp; (4) from silica rocks. Searles Lake presents a serious unsolved problem of the separation of KCl from a large number of other salts. The Pacific Chemical Co. is constructing a plant for the utilization of "vinasse" from sugar industry. The Kelp Products Co. is operating an experimental plant, with no output as yet.

"Other than wood ashes and vegetable refuse (7) there are four potential sources of potash in the United States; subterranean brines and salt lakes in the West, kelp, feldspar, and known deposits of the alunite type." "Assuming a satisfactory solution of the technical problems, there still remain certain economic problems to be considered, which make it doubtful if kelp will develop into a source of a large amount of potassium salts. The concentration of potash in the brines is so low in comparison to other salts that it is doubtful whether the extraction will ever be commercially possible." "There are no technical difficulties involved in the production of potassium sulphate, impure alumina, and sulphuric acid from alunite." There is no ready market for the sulphuric acid or the alumina. Feldspar investigation still goes on with no production. An industry can be established if there were a guarantee of no price cutting on the part of the Germans.

De Beers (8) groups our sources of potash under by-product and main product plants. Under the former is included wood ashes, bittern, wool, sugar, cement, blast-furnace, and under the latter, kelp, alunite, lakes, and feldspar. Production is now realized from wood ashes, bittern, notably Nebraska lakes, wool, cement, blast-furnace, alunite and kelp. Kelp cannot become a permanent source because of high cost of production. Searles Lake will be an increasing factor in the industry. No productive process for feldspar has yet been produced.

Ebaugh (9) by means of charts and tables shows conclusively the emergency resulting from the embargo on German potash. All efforts so far have been of the "war baby" type. Real success of a potash industry lies in the successful utilization of natural wells, such as feldspar, leucite and alunite.

In an editorial (10) on the potash industry it is pointed out that although natural brines, especially Nebraska lakes, are quite productive, it is doubtful if development will survive a return to normal conditions. Searles Lake presents a real factor in the industry, while kelp, after the war, will not prove a profitable field in spite of over $4,000,000 investment, unless the Government Experimental Plant brings in positive results. Potash from rocks is difficult to extract, but it is not possible that that problem will forever remain unsolved.

Meade (11) groups the present methods used for getting potash in the United States under four general heads: (1) Evaporation of brines; (2) kelp and ashes of plants; (3) byproduct from cement, iron, beet sugar, and molasses; (4) decomposition of silicate rocks, especially alunite, glanenite and feldspar. The Nebraska lakes which would promise most under normal conditions and which are reported at the present time to be making a large amount of money, are quite limited as to brine supply, and unquestionably they could only furnish a small part of the potash which has been shipped from Germany. The development of Searles & Owens Lakes depends on a market for soda ash and salt cake. The possibilities of the production of potash salts from kelp on a large scale do not seem to be particularly bright as a post-war proposition. The possibilities for developing an industry in connection with cement and blast-furnaces is excellent. In the processes proposed for the utilization of silicate rocks the quantity of potash produced compared with the by-product is negligible, and under normal conditions its value is generally less, so that with most of them potash is really the by-product and the other constituent the main one. Proper legislation is necessary to protect the industry from the foreign producer.

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According to Maizeres (23), the production of the German syndicate in 1911 was 9,399,269 metric tons of salt.

Maizeres (24) and MacDowell (25) give figures on production by German syndicate in 1912. Total salts mined, 11,164,000 tons salt, representing 1,100,000 tons K_2O.

The production in 1913 (26) was 13,000,000 tons of crude salt, or 1,413,833 tons K_2O.

Reference (27) gives the world's production in 1914, while (28) gives a summary of the statistics for imports into the United States during the month of May and five months ending May, 1914 and 1915.

MacDowell (4) gives German production for 1912 at 11,164,000 tons of salts; Cresswell (5) for 1911, 9,706,507 tons, Ebaugh (9) for 1913, 1,721,079 metric tons of K_2O.

Salcedo (29) discusses the potash production in Chili.

Commerce Reports (30) (31) for 1915 contain information on the developed deposits in Spain.

Kalski (32) describes the deposits in Kalusy, Austria.

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References (44) to (45) deal with the lakes in Nebraska and give data on the industry in that locality.

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SILICATE ROCKS

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Chemistry Department,
University of Kansas,
Lawrence, Kan.

The Kelp-Potash Plant of the Lorned Manufacturing Company

An interview with
LESLIE H. THOMPSON, VICE-PRESIDENT

KELP is a marine plant of high potash content. There are several varieties of potash-bearing kelp, but the only one that concerns the potash producers of Southern California is *Macrocystis Pyrifera*. Macrocystis occurs rather abundantly off the mainland and surrounding the coastal islands from Point Conception above Santa Barbara to below the Mexican border. It is attached to the bottom of the ocean by a root-like anchorage called a "hold-fast," and its stems or stripes are sometimes as much as 150 feet long. At the base of the leaf where it grows out of the stem is a pneumaticist, or bulb of air, which holds the strand of kelp on the surface of the water. The rate of growth and the growing period or seasonal growth are still mooted questions. While it is believed that kelp grows all the time, it appears that there are periods when the growth is more luxuriant than others. Our observation leads us to believe that there are two main growing periods about six months apart. The larger and better growth of the two is from July to September, the other from January to April. As a general thing two crops a year, and under some conditions three crops a year, may be harvested.

General control of the kelp beds is vested in the California Fish and Game Commission, which has surveyed, mapped and numbered the various areas capable of being harvested. The Commission exercises supervision over the beds, closing those which have been cut while they attain a regrowth, in such a way as to conserve the supply to the greatest possible advantage. Dr. W. C. Crandall of the Scripps Institution for Biological Research is a special deputy of the commission, and at the Institution scientists are making a thorough study of the growth and habits of kelp.

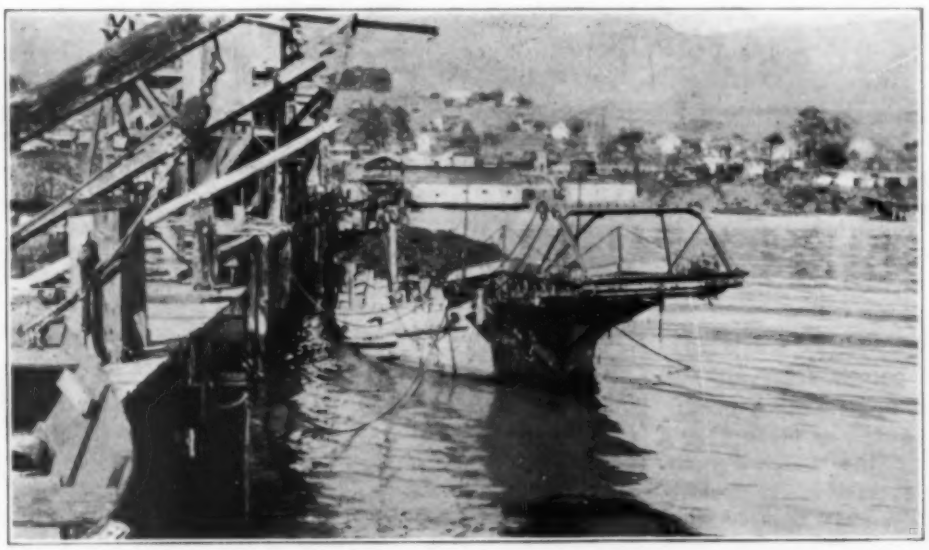

FIG. 1.—THE "ABION" LYING AT UNLOADING PIER

The chief manufacturers of kelp products are located at San Diego, Long Beach and Summerland (near Santa Barbara). The San Diego manufacturers harvest Macrocystis up the coast from the Mexican boundary to Laguna, and include the islands of San Clemente, Santa Barbara and San Nicolas. The manufacturers at Long Beach harvest up the coast from Long Beach to Rincon Point. The manufacturers at Summerland harvest from Carpentaria to Naples. The territory west of Naples and the Santa Barbara Channel islands of San Miguel, Santa Rosa, Santa Cruz and Anacapa, are considered open territory.

THE PROBLEM OF HARVESTING

The first and most unique problem before the seekers of potash from kelp was that of effectively harvesting the weed itself. It should be understood that the plant contains approximately 90 per cent water, which means that a tremendous bulk of the raw kelp must be handled before a modest amount of potash can be secured. While the methods of harvesting in use by the various manufacturers are similar in principle, there is some variance in the details. Fig. 1 shows a view of the Lorned harvester "Albion," which is equipped with two 60-hp. engines. It has a capacity of 130 tons of wet kelp on deck. The cutting apparatus consists of a horizontal cutter bar equipped with oscillating knives similar to an ordinary mower. At the end of this horizontal cutter bar, which is 12 feet long, are two vertical cutter bars 4 feet long, equipped with the same kind of knives. The cutter is lowered into the water so that the horizontal cutter bar is approximately 4 feet below the surface, and as the kelp is cut it is carried up and deposited on the deck by a draper or slat conveyor. As the kelp accumulates in the bow of the boat under the draper, it is hauled back by means of a grab-hook operated by a winch, so that the load is kept properly distributed as fast as it accumulates. This harvester carries a crew of six men—a captain, engineer, winchman, cutterman, and two hookmen. This is a seaworthy boat, and can operate in fairly rough weather. It has a speed of nine miles an hour, and in thick kelp can harvest fifty tons an hour.

On returning, the loaded harvester docks alongside the unloading pier underneath telpher track extending out from above a receiving hopper. A grab-hook, built like a clam-shell bucket, having a capacity of about 1500 pounds of kelp at a grab, unloads the barge, all lines being handled from a double-drum electric hoist. The unloading is done by an unloading crew of three men. About 30 tons an hour are unloaded in this way.

CUTTING AND CONVEYING

This receiving hopper has but a moderate capacity, it being large enough to catch merely one grab-hook of kelp and feed it through a chopper (an ordinary ensilage chopper with certain extra controls) which cuts the

kelp into lengths averaging about 12 inches. The chopped kelp drops into a drag conveyor, shown in Fig. 2, motor-driven at approximately 120 feet per minute, leading in three flights 700 feet in shore to a 300-ton hopper-bottomed storage bin. This storage bin is divided into two sections with a capacity of 150 tons each. The conveyor is merely a wooden flume with a pair of link chains along the bottom, to which cross-boards or slats are bolted at short intervals. The kelp itself is very slippery—its slimy exudation effectually lubricates the surfaces of contact between chain or flight and conveyor bottom.

In the above manner the kelp is cut, conveyed and discharged into an empty section of the storage bin as rapidly as it is unloaded from the barge.

Heaped kelp bleeds a yellowish, slimy substance, which contains about as much potash as the weed itself. This juice dripping from the storage bin is carefully caught on a tight subfloor, and drained into a concrete supply tank from which it is pumped into pans placed below and above the hot end of the rotary incinerators

FIG. 2.—VIEW FROM STORAGE BIN

and evaporated to dryness by the radiating heat which would otherwise be wasted. The solids remaining are a dark purple crystalline mass containing about 25 per cent K_2O.

The V-shaped bottom of the kelp storage-bin is closed by a series of loose, horizontal boards, directly underneath which runs a drag conveyor such as formerly described, leading to the kiln room. One laborer is in the storage bin at all times, feeding or regulating the flow of the slippery sea weed to this conveyor. As the contents of the bin are unloaded back to a slope where considerable hoeing is required to keep a constant discharge, another one of the horizontal boards is removed at the toe of the slope. In this manner the bin is progressively emptied at a rate depending upon signals from the kiln room.

Incinerating the Kelp

A stream of wet kelp coming in this manner from the storage bin is discharged into four rotary dryers by one of a pair of tilting-box feeders (Fig. 3), set between and above their hot ends. Thus at intervals of about 14 seconds either kiln receives a charge of 15 pounds of material. The kilns themselves are merely unlined horizontal cylinders of steel plate, 42 feet long by 7 feet in diameter, set at a slight incline from the hot end downward toward the discharge end ($\frac{1}{16}$ of an inch per foot), so that the contents will progress slowly forward as the cylinder rolls. Twelve rows of hooks, as shown

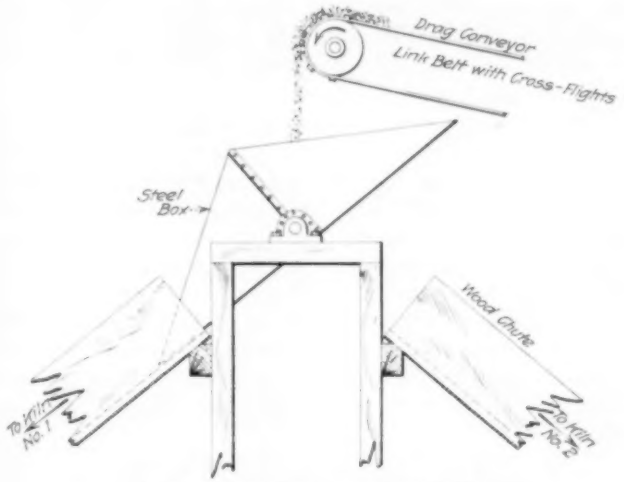

FIG. 3.—TILTING BOX FEEDER

in the sketch, Fig. 4, are affixed to the interior of the shell in order to lift the wet shreds and drop them through the heated air within the kiln.

The kiln itself is fired by two oil burners, the fuel supply coming from wells in the immediate vicinity. The oil flame is confined within the limits of a relatively large "Dutch oven," 21 by 12 by 9 feet, set directly in front of the kiln itself. In this way a stream of gases of combustion and hot excess air enters the kiln, coming first in contact with the wet kelp at about 1400 deg. F. These gases partly dry the material in their passage, leaving at the far end loaded with moisture and cooled to a temperature of approximately 250

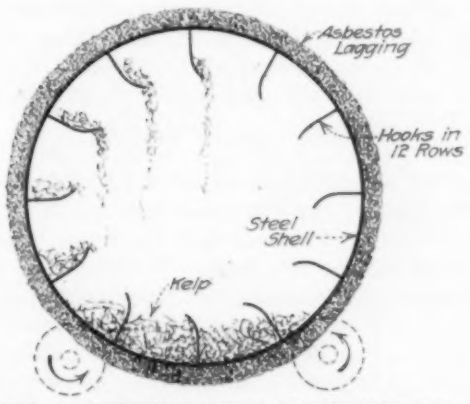

FIG. 4.—INTERIOR KILN CONSTRUCTION

deg. F. The temperature of the exit gases is kept under constant observation by means of a recording pyrometer; should the temperature show a tendency to rise the feeder in the storage bin is notified to increase the flow of wet material, and *vice versa*. The moisture content of the weed discharged from these preliminary driers has been reduced from 90 per cent to about 25 per cent, the actual evaporation depending in large part upon the amount of work which can be performed in the incinerator, described later. The

appearance of the kelp at this point is markedly changed; the wet, green, slippery plant is now shriveled into dark brown, tough, leathery pieces, dry to the touch. Sometimes the leaves have burned to a char around the edges; these thin brittle borders are then pulverized during their travel through the kiln and are largely swept away with the furnace gases as dust. The moisture evaporated in these dryers is approximately 13 pounds per pound of fuel oil, using a fuel oil of 12 deg. Baumé, specific gravity 0.986, calorific power 18,500 B.t.u. per pound.

Two incinerators receive the discharge from the four dryers. These are merely rotary kilns 40 feet long and 5 feet in diameter, similar in construction to the preliminary dryer, except that they have no furnace or oven, the oil flame shooting directly into the drum. In this kiln the flame further dries the kelp and burns off the volatile hydrocarbons, producing a hot, grayish charcoal containing 35 per cent K_2O. The discharge falls into wheel-barrows and is immediately spread in long narrow ridges or "wind rows" on a cooling floor of concrete, where its heat quickly radiates into the atmosphere.

Recovery of Dust from Dryers

Furnace gases and moisture are drawn off from the rotary dryers by suction fans placed at the discharge end. The size of these fans averages 42 inches in diameter, with a capacity of 6000 cubic feet per minute, speed 900 r.p.m. Approximately 10 horsepower is required to operate each fan. A similar fan is used at the end of the incinerators to produce a draft necessary to complete combustion. Both in the preliminary dryers and in the incinerator a portion of the charge breaks into the finest particles, which are swept out by the furnace gases. This dust is of course quite valuable, and at the Lorned Manufacturing Co. the furnace flues lead to a series of brick dust chambers where the velocity is reduced to such a point that nearly all the dust is precipitated. At the end of the dust chamber the smoke passes through sprinklers to wash it thoroughly before allowing it to escape into the air. An average of 15 tons of dust, having a content of 30 per cent K_2O, is recovered from the dust chambers each month.

Product Used as Fertilizer

After the charcoal has cooled it is fed into a screw conveyor leading to the crushing plant, which is equipped with a Williams mill having a capacity of about 2000 pounds per hour. The resulting product, amounting to approximately six tons per day, is bagged on platform scales in sugar sacks containing 125 pounds each of fine ash. The sacks are stored until shipment in a nearby warehouse. A ready demand exists in the Southeastern fertilizer market.

The process as described above is admittedly crude. Many valuable products can be made from kelp, which are absolutely lost by this method. It has, however, the advantage that it produces potash, which is doubtless the one product most keenly needed just at present, in a plant readily operated without close technical control or a staff of highly skilled operatives.

As to the future of the industry, one may turn to various authorities. Meade[1] estimates that the efficiency of the rotary dryers amounts to 70 pounds of water per gallon of oil, and that 1900 gallons of oil must be burned to produce one ton of potash. He therefore concludes that "the possibilities of the production of potassium salts from kelp on a large scale do not seem to be particularly bright as a post-war-time proposition. The cost of . . . fuel alone under ordinary conditions would eat up most of the price obtained for the product." On the other hand, Laucks[2], citing his experience in drying kelp in the Northwest, quotes a harvesting cost of 43 cents per ton of kelp, unloading at 6 cents, and drying from 25 to 50 cents per ton of green kelp, using a rotary drier and hogged wood-waste as a fuel. Under these conditions, which evidently represent prices before the recent inflation, and which happily may be attained again, Laucks thinks that a product containing 28 per cent KCl, 2 per cent nitrogen, and 10 per cent water can be worked at a profit if the price for 80 per cent muriate remains above $35 per ton. J. W. Turrentine, the government expert in charge of their experimental plant, on the other hand, writes,[3] "The giant kelp of the Pacific Coast still offers the best promise of supplying the proper conditions for the establishment of a domestic potash industry. Thus, they occur in sufficient quantity, they are accessible, and the product under normal conditions may be delivered at the market—the Atlantic seabord—at a charge for freight that is not prohibitive."

The real truth may lie somewhat between these optimistic and pessimistic statements. Purely as a producer of potash by evaporating methods, kelp is at a distinct disadvantage against the Nebraska lakes. For instance, each has to evaporate about the same amount of water to get a ton of K_2O, and so far they have even chances; but it evidently costs much more to harvest a marine plant than to pump salt water. The future of kelp seems to lie in the recovery and use of the various by-products. The wet fermentation method developed with such marked success by the Hercules Powder Company,[4] produces potassium chloride, acetone, iodine, ethyl acetate, propionate and butyrate in commercial quantities, but requires a very expensive plant and high technical equipment. The dry distillation process now being developed by the United States Department of Agriculture in their experimental plant at Summerland, California, and in the forest products laboratory at Madison, Wisconsin, may prove more economical in first cost than the other. Potassium chloride, iodine, charcoal and distillates will be the chief products, and the success of their ideas will probably depend in large part upon the uses discovered for the latter two.

[1] Met. & Chem. Eng., July 15, 1917.

[2] Ibid, March 15, 1916.

[3] Ibid, Feb. 15, 1917.

[4] Ibid, June 1, 1918.

Potash and Kali

Kali, the German word for potash, comes down directly from Sanskrit, the ancient language of the Hindoos. Kali was their name for the black destroying goddess, who had numerous arms and red-palmed hands. Her eyes were red and her face and breast besmeared with blood. The name of the city, Calcutta, is derived from Kalighat, which, translated, means Kali's landing place. No doubt, Kali is just as plain and as representative a name for burned wood as our term potash.

The Potash Industry of Germany

Theories of Origin and Description of the Strassfurt Salts Deposit—The Present Status of the Industry—Its Economic Aspect

BY WALLACE SAVAGE

POTASH is one of the most abundant of the chemical elements, constituting about one-fortieth part of the mineral crust of the earth. In the formation of the fused glassy rocks such as the granites, micas and feldspars, it has contributed to a very great extent to their weather enduring properties, upon which the maintenance of land above sea level, the habitation of man, is largely dependant. How resistant these mineral potassium silicates have been to the ages of weathering in the past is obvious upon examination of the rocky peaks of the mountain ranges, or can be deduced from analyses of the ocean brine, the continental wash waters of all ages in concentration. Sea water will be found to consist essentially of sodium and magnesium salts in its three and one-half per cent of dissolved matter. Table I gives an analysis made by Regnault of the eight most important sea brine constituents.

TABLE I—ANALYSIS OF SEA WATER

	Per Cent. Solids	Per Cent Brine
Water	00.00	96.47
Sodium chloride	76.49	2.70
Magnesium chloride	10.20	0.36
Magnesium sulphate	6.51	0.23
Calcium sulphate	3.97	0.14
Potassium chloride	1.98	0.07
Calcium bicarbonate	0.08	
Magnesium bromide	0.06	0.03
Miscellaneous	0.71	

However, judging alone from the preponderance of sodium, magnesium and calcium salts shown here, one could not derive numerical deductions, for a great part of the decomposition products of the minerals are absorbed largely and variously in animal and vegetable growth of an unknown amount. Table II gives the weights of salts in the ashes of normal crops from an acre of ground in the order of their average proportions.

TABLE II—POUNDS OF VEGETABLE ASH—ACRE CROP

	Grain	Straw	Roots	Tops	Hay
Silica	14.71	233.08	27.03	2.67	78.23
Potash	14.39	32.73	142.66	88.82	38.22
Lime	2.24	27.62	46.24	72.14	44.45
Phosphate	35.76	10.56	25.77	28.80	15.12
Sulphate	0.12	13.15	46.24	38.81	9.20
Chloride	0.02	3.55	12.24	49.75	4.06
Magnesia	7.60	12.14	18.16	9.58	7.09
Soda	7.05	1.21	17.31	16.76	12.05
Iron oxide	1.11	5.96	4.35	2.67	0.58

In the cycles of primeval vegetation, the mineral matter of all organic life was returned to the soil upon its inevitable decay at the place of growth. However, when man ceased to be an inhabitant of the forest, and the population became engaged in urban and agrarian pursuits, the extraction of the mineral salts from the soil began on an ever-increasing scale. Upon examining the table, the effect of the modern root crops, sugar beets and potatoes, in respect to potash, will be seen to be very great, 231 lb. being absorbed to the acre. Still more important did this become, when it was found that growth ceased as the available potash etc. became exhausted. In 1860, A. Frank, chemist in the sugar refinery of Bennecke and Hecker at Stassfurt, worked out a process for extracting potassium chloride from the overburden salts, "abraumsalze," of the local rock salt mine, the two shafts of which had been completed in 1852. The manufacture of potash salts was then instituted, which became absolutely essential as a fertilizer to the German sugar beet, potato starch and alcohol industries.

THE STASSFURT SALT INDUSTRY

During ancient times in Germany, before the era of the manufacture of iron pipes, salt was not transported long distances, but was obtained from the nearest brine springs, which were numerous, on account of the underlying strata of rock salt located there. In the lowlands north of the Harz Mountains, the flow of ground water toward the sea, due to the water head from the mountain slopes and the impervious strata formation of the soil, gave rise to many brine springs, the sodium chloride content of which, however, though not large, was exceptionally pure—the slight content of bitter foreign salts having been dissolved and entirely carried away from the leached residues of the deposits adjacent to the underground water currents.

Starting in about 1785, many wells were drilled in different parts of Europe. Prior to 1825, enormous beds of rock salt were located at many places in Wurttemberg, Hess, Baden, Lothringia, Langenberg, Kostritz, Koburg-Gotha, etc. Crude salt soon became so abundant that its main costs were in government tax fees and transportation charges. In 1839, the Konigliche Saline at Stassfurt gave up evaporating brine and began prospect work to determine the local availability of mineral salt as pure as that derived from their spring brine. In August, 1843, their drill struck salt at a depth of 832 feet, and after years of difficult work they drove into solid salt about 1000 feet, stopping on May 31, 1851, without reaching the base of the deposit. The well was a disappointment qualitatively, as the brine obtained from it had a very bitter taste.

Geheim Bergrat von Carnall decided that a shaft would be necessary to determine whether a separate layer of pure edible salt was situated at the source of the brine spring. Handelsmeister von der Heydt ordered two shafts sunk, which were started in the winter of 1851. At the ceremonies celebrating the opening, a crier went about Stassfurt calling: "Fellow citizens! Great opportunities will arise in the future for our industrial expansion! Just as there has been in the case of the sugar refinery, so will there be in this far more important undertaking!" How majestically this prediction was to be fulfilled could not have been foreseen in these days of wood fuel and ample supplies of potash from wood ashes. It was exactly these accompany-

ing mineral salts, potassium and magnesium chlorides, an undesired impurity in table salt and without a market at the time, which were to become the corner stone of German strength in international commerce in chemicals, the absence of which were indicated initially by the purity of spring brine, because in reality, they were sealed from the ground water by impervious strata of clay and gypsum but for the protection of which they would long since have been dissolved by the ground water and disseminated far and wide.

Prospecting the Stassfurt Deposit for Potash

From the amount of boring that followed in subsequent years, the deposit of potassium salts appears to cover an area of one hundred square miles, principally located in Anhalt and Prussian provinces of Saxony and Hanover. At an early date Anhalt, recognizing the agricultural and financial value of such deposits, declared the rights of exploration a state monopoly, which was later contracted to a few private companies. In Saxony, prospecting rights were free and the mining concessions belonged to the first discoverer of the deposits without regard to the owner of the surface soil. According to the laws of Hanover, the property holder owns all the mining rights.

Under such a variety of laws, the deposit has had unhampered exploitation. Speculators have paid as high as $12 per foot for diamond drill cores to establish their claim for concessions. Stock companies were formed in great numbers. The older companies, fearing overproduction and falling prices, banded together against newcomers. The earlier members of the syndicate, with the year of their starting mining and their production allotments for the four following divisions are given in Table III.

Class I Products more than 48 per cent K_2O.
Class II Products 48-18 per cent K_2O.
Class III Products 18-12 per cent K_2O.
Class IV Products less than 12 per cent K_2O.

TABLE III—KALI-SYNDICATE (1900)

	I	II	III	IV
Der koeniglich preussishe Fiscus, Stassfurt, 1852	130	130	130	142
Der herzoglich anhaltische Fiscus, Leopoldhall, 1857	118	118	120	110
Consolidirte Alkaliwerke, Westeregeln, 1871	100	100	102	100
Salzbergwerk Neustassfurt, Stassfurt, 1877	100	100	102	100
Gewerkshaft Ludwig II, Stassfurt, 1881	72	72	26	80
Kaliwerke Ascherleben, Ascherleben, 1882	100	100	102	100
Gewerkshaft Hercynia, Vienberg, 1884	93	93	101	100
Deutsche Solway-Werke, Bernberg, 1885	100	100	102	100
Thierderhall, Thiede, 1885	46	46	48	48
Wilhelmshall, Auderbeck, 1887	61	61	85	70
Gewerkschaft Gluckauf, Sonderhausen, 1893	40	40	70	...
Gewerkschaft Hedwigsburg, Wendessen, 1895	40	40	60	50
Gewerkschaft Burbach, Beendorf, 1897	...	Independent		...
Schmidtmanhall, Leopoldhall, 1883	...	Independent		...

Theory of the Formation of the Stassfurt Salt Deposits

The colassal size of the salt deposits which have been disclosed in Northern Europe has created much speculation upon the part of geologists and chemists as to the manner of their formation. For detailed discussions on the subject, the reader should consult the German treatises[1].

Summarizing the studies of his predecessors, C. Ochsenius explained the origin of the deposit by the evaporation of sea brine in land-locked basins near the ocean shore at the time of the Permian formation, which bodies of water were shut off from the open ocean by sand bars at the connecting inlets, thus forming land-locked salt lakes. Such a formation can be seen at the present day on the east side of the Caspian sea. The surface of this Caspian lake, which is connected to the open sea by a shallow canal 225 yards wide and 1 yard deep, is 585 square miles in area with a depth of 16 yards. In the summer a thick layer of salt crystalizes out. Upon comparison of the solubility curves in Chart I with the analysis of sea water, Table I, it will be seen that ocean brine is 10 per cent saturated with sodium chloride and only 1 per cent with magnesium chloride. While intra-ionic and physical affects vary the solubility of these salts in the presence of each other, it can be readily seen that a dead sea would have to be concentrated one hundred times by means of evaporation and decrease in volume, due to the space occupied by the deposited sodium chloride, before the bitter salts would separate from their solution.

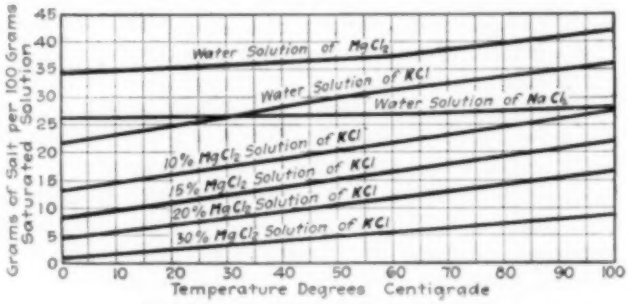
Grams of Salt per 100 Grams Saturated Solution
Temperature Degrees Centigrade
Water Solution of $MgCl_2$
Water Solution of KCl
Water Solution of NaCl
10% $MgCl_2$ Solution of KCl
15% $MgCl_2$ Solution of KCl
20% $MgCl_2$ Solution of KCl
30% $MgCl_2$ Solution of KCl

CHART I.—SOLUBILITY CURVES

Upon inspection of the salt deposits at Stassfurt, thousands of segregated strata of salt from 3 to 4 inches thick will be found. During the changes in the weather, when probably the "September gales" dashed the sea over the inlet bars, new brine charged with lime salts entered the dead sea and there was immediately deposited a thin blanket of anhydrite ($CaSO_4$) which has become known as the year ring from analogy with the lines in tree growth. The number of these rings indicates that ten thousand years were occupied in the deposition of the rock salt and in the accumulation of the saturated solution of magnesium and potassium salts.

Finally, either the bars grew to greater size or the weather grew milder and the barriers completely isolated the lake of accumulated minor brine salts from the ocean. Polyhalite (K_2SO_4, $2CaSO_4$, $MgSO_4$, $2H_2O$) first crystalized, then kieserite ($MgSO_4$, H_2O), next carnallite (KCl, $MgCl_2$ $6H_2O$), and then fortunately clay, gypsum, sandstone and diluvial and alluvial formations sealed the deposit securely as is shown in Fig. I of the Leopoldshall deposit. The period for the entire formation down to the 3300-foot level of the salt deposit has been estimated at about 15,000 years.

A few investigators believe that the ocean was not the source of the brine and that the salts were the direct decomposition products of the rocks from the Harz Mountains. An example is offered at present in the case of the historic Dead Sea and the river Jordan. In recent times van't Hoff, in coöperation with many other chemists made an investigation on the crystali-

[1]Beschof, "Die Steinsalzwerke bei Staszfurt." E. Pfeiffer. "Handbuch der Kaliindustrie." Furer, "Salzbergbau und Salienenkunde." Precht, "Die Norddeutsche Kaliindustrie." Ochsenius, "Die Bildung der Steinsalzlager und ihrer Mutterlaugensalze." Walther, "Das Gesetz der Wurtenbildung." Van't Hoff, Sitzungsber d. Kgl. prensz Akad. d. Wissensch. Zn Berlin 1897-1908; "Zur Bildung der Ozeanischen Salzablagerungen."

zation of these salts from their solutions. The physical conditions of temperature and pressure necessary for the formation of every salt formed in the Stassfurt deposit were determined. From the interpolation of his results, van't Hoff concluded that the prevailing

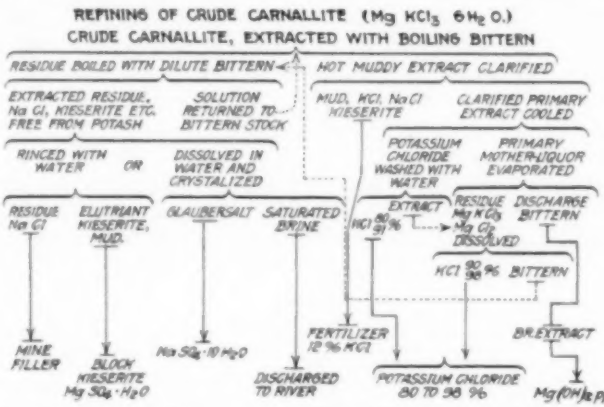

CHART II.—DIAGRAM OF EXTRACTION OF CARNALLITE

temperatures during the period of formation was from 77 to 163 deg. F. If the brine corresponding to the deposited salts should be superimposed over the deposit, it would be fifty miles deep, which would indicate that an average of one rod of water was evaporated annually. Reasoning from such figures, one is led to conclude that conditions for air evaporation were exceedingly favorable during the Permean period.

Concentrating Potassium Chloride

The average analysis of crude carnallite is given in Table IV.

TABLE IV—ANALYSIS OF CRUDE CARNALLITE

	Per Cent
ater	26.2
Sodium chloride	21.5
Magnesium chloride	21.3
Potassium chloride	15.6
Magnesiu s lphate	13.0
Gypsum mud	2.0
Miscellaneous	0.4

The solubilities of a double solution of magnesium and potassium chlorides in varying ratios are shown in Chart I. The depression of the solubility of the potassium by magnesium chloride can not be carried to the extreme, however, for when the ratio of the latter to the former is more than three to one, $MgCl_2$, KCl, $6H_2O$ crystalizes out.

For this reason, hot solutions and cold crystalizations are made, the temperature increasing the solubility several per cent of both these salts. Sodium chloride does not become materially more soluble upon boiling, so that what dissolves does not crystalize out on cooling, but passes away with the mother liquor. The scheme of the process used in the average refinery is given diagrammatically in Chart II. Sylvine is a secondary salt found at many places where ground water has had limited access and has carried off the more soluble magnesium salts, leaving sodium and potassium chlorides. This is easily refined by solution in hot brine, potassium chloride being alone supersaturated upon cooling. While many elaborate types of digesters have been developed for use in this industry, space will not be taken for their description.

Potash Costs in Germany

About nine years ago there arose an illuminating price controversy between the Schmidtmann Company and the syndicate. Table V gives the wholesale prices for 1910 contracts made for American imports. It is

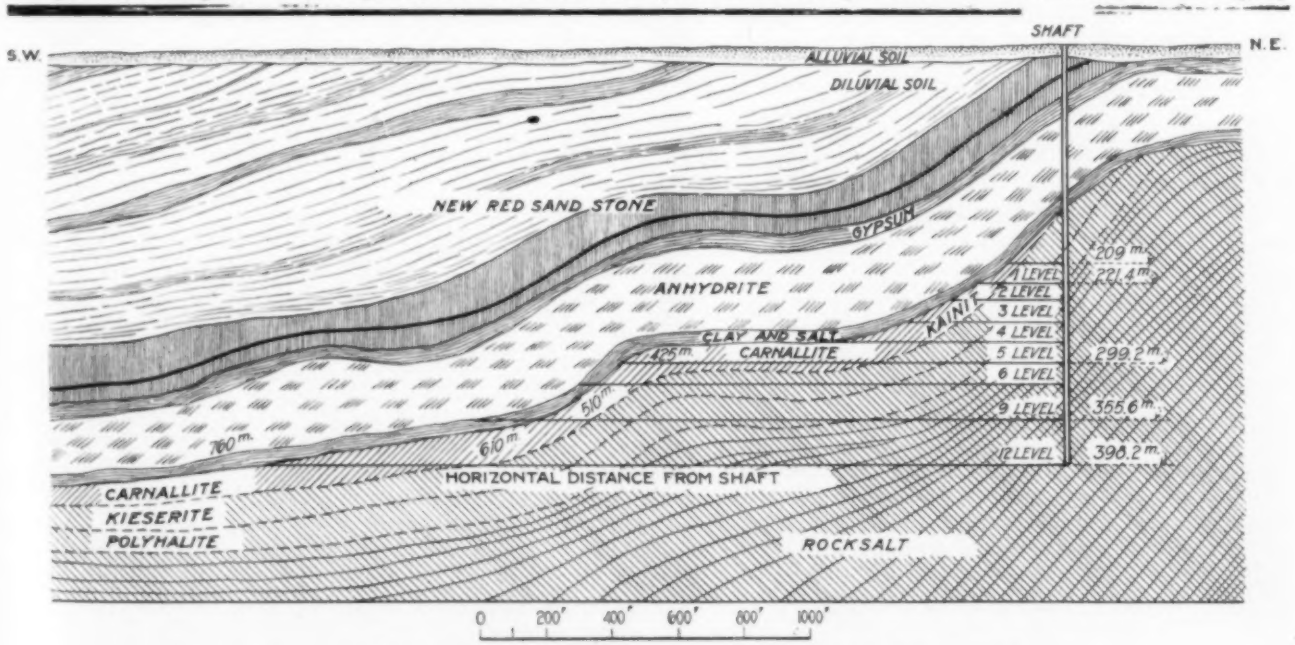

FIG. 1.—CROSS-SECTION OF THE SALT DEPOSIT AT LEOPOLDSHALL

TABLE V—WHOLESALE PRICES PER LONG TON—1910

	Schmidtmann F.o.b. MINE	Schmidtmann C.i.f. U. S. A.	Syndicate Net C.i.f. U. S. A.
Concentrated salts:			
Muriate	$15.54	$20.40	$32.98
Sulphate	20.94	25.80	38.80
Double manure	9.28	14.14	20.37
Thirty per cent manure	8.42	13.28	.....
Crude salts:			
Kainit	1.92	5.16	7.03
Hartsalz	2.48	5.72	8.73
Twenty per cent manure	3.89	7.13	11.64

certain that the Schmidtmann mine could operate profitably at these prices, though of course this mine is recognized as one of the most efficient. This fixes $15 per ton as an approximate cost of a 50 per cent K_2O. At the present time, under war conditions, potash salts are selling in Germany for 27 pfennig per unit K_2O per 100 kilos, which is equivalent to about $32 per ton for normal muriate.

War-Time Production

Of the 52 concerns having "Kuxe" (shares), 46 have higher quotations than those prior to the war, though none are operating with a margin of profit sufficient to declare a dividend. All of the producing mines have been reorganized into a new government backed "Verkaufsyndicat" and the annual production fixed. Table VI gives the figures for the present year; the domestic

TABLE VI.—ALLOTMENTS FOR 1918

	Per Cent K_2O	Tons	
		Domestic	Foreign
Crude salt	.....	2,700,000	.....
Fertilizer	(20-22)	50,000	540,000
Fertilizer	(30-32)	91,000	75,000
Fertilizer	(40-42)	3,920,000	630,000

consumption will be noticed to be very high because the government has encouraged the planting of the potash crops, *i.e.*, potatoes, beets, etc., to make as large a food tonnage as possible. Upon reference to Table II, it will be appreciated that a shortage of American phosphates must be taking serious form by now in view of their intensive agricultural production.

Future Potash Production

Ordinarily one will be guided in predicting the future by the direction of the trend of affairs in the past. Therefore, in the present case, it seems preferable to give the following tables, which are so clear that they interpret themselves. The great agricultural demand for potash is due to modern crop transportation—something must be returned to the soil.

If the annual production of Stassfurt salts were plotted since 1862, the rate of increase would be found to be fairly constant, showing that the consumption of potash salts depends practically on the capacity of the mines to produce. Should the prices advance materially and production be restrained from flooding the markets through the German government controlling the mines, an interesting problem will be opened for the economists of the potash importing countries. No doubt the United States could retaliate on some of its exports of essential need in Germany; moreover, who can tell but that a similar salt formation exists in America. We have drilled into petroleum when we expected salt, and obtained pure sulphur where oil was thought to be the certain reward. At any rate, our by-product potash industry will be a permanent source of supply for a considerable proportion of our requirements.

PRODUCTION OF STASSFURT CRUDES

Year	Kainit M. Tons	Carnallite M. Tons
1865	1,313	87,670
1866	4,900	135,553
1867	8,351	141,604
1868	10,463	167,336
1869	16,857	211,883
1870	18,877	268,225
1871	32,695	335,944
1872	17,851	468,537
1873	6,094	441,078
1874	9,751	414,961
1875	23,818	498,736
1876	17,776	563,669
1877	33,305	771,819
1878	32,480	735,750
1879	48,827	610,427
1880	137,795	528,210
1881	155,301	744,726
1882	144,757	1,059,299
1883	226,600	950,203
1884	203,004	739,958
1885	245,911	644,709
1886	240,552	698,229
1887	237,570	840,206
1888	319,110	849,602
1889	320,694	798,721
1890	358,125	838,525
1891	467,244	818,862
1892	545,084	736,750
1893	648,315	794,659
1894	690,786	851,338
1895	649,152	782,944
1896	829,686	856,223
1897	975,814	851,272
1898	1,083,476	990,998
1899	1,108,159	1,384,972
1900	1,178,527	1,874,346
1901	1,500,748	2,036,326
1902	1,322,633	1,962,384
1903	1,557,243	2,073,720
1904	1,905,893	2,178,471
1905	2,387,643	2,655,845
1906	2,679,264	2,821,073
1907	2,624,412	3,124,955
1908	2,715,487	3,383,535
1909	3,181,349	3,860,685
1910	4,249,667	4,062,004
1911	4,425,497	5,181,379
1912	5,889,238	5,271,964

PRODUCTION OF POTASSIUM SALTS IN GERMANY

Year	Kainit Quantity M. Tons	Kainit Value	Potassium Salts Other than Kainit Quantity M. Tons	Potassium Salts Other than Kainit Value	Potassium Chloride Quanity M. Tons	Potassium Chloride Value	Potassium Sulphate Quantity M. Tons	Potassium Sulphate Value	Potassium Magnesium Sulphate Quantity M. Tons	Potassium Magnesium Sulphate Value
1898	1,103,643	$3,835,856	1,105,212	$3,576,628	191,347	$6,380,220	18,853	$763,397	13,982	$259,485
1899	1,108,159	3,838,250	1,384,972	4,202,000	207,506	6,801,250	26,103	1,027,500	9,765	195,000
1900	1,178,527	4,134,000	1,874,346	5,643,750	271,512	8,793,750	33,853	1,249,250	15,368	280,500
1901	1,500,748	4,327,250	2,036,326	5,443,250	282,750	8,782,250	27,304	1,460,000	15,612	286,500
1902	1,322,633	4,571,980	1,962,384	4,949,448	267,512	7,507,710	28,279	1,079,092	18,147	334,390
1903	1,557,243	5,208,154	2,073,720	4,993,478	280,248	8,125,320	36,674	1,389,444	23,631	441,252
1904	1,905,893	6,322,470	2,179,471	5,305,972	279,238	8,425,676	43,959	1,664,572	29,285	545,972
1905	2,387,643	7,976,808	2,655,845	6,396,250	373,177	10,580,528	47,994	1,804,040	34,222	614,754
1906	2,720,594	8,918,574	2,821,073	6,538,336	403,387	11,034,632	54,490	2,032,520	35,211	644,028
1907	2,624,412	8,579,206	3,124,955	7,314,930	473,138	12,639,704	60,292	2,216,494	33,368	631,652
1908	2,715,487	9,196,082	3,383,535	7,720,006	511,258	13,369,174	55,756	2,037,518	33,149	663,068
1909	3,181,349	10,646,792	3,860,685	8,787,198	624,994	16,245,642	68,539	2,574,684	38,722	697,816
1910	4,249,667	12,712,056	4,062,004	9,034,004	741,259	17,371,144	84,583	2,989,756	37,439	668,066
1911	4,425,497	13,757,452	5,181,379	11,794,328	838,420	19,851,342	107,631	3,967,460	42,253	780,974
1912	5,889,238	18,178,916	5,271,964	10,294,214	506,744	16,336,792	123,407	4,848,714	54,435	*(b)*

POTASSIUM SALTS IMPORTED TO THE UNITED STATES

	1911 Quantity	1911 Value	1912 Quantity	1912 Value	1913 Quantity	1913 Value	1914 Quantity	1914 Value	1915 Quantity	1915 Value
Bicarbonate	163	$16,428	138	$13,155	156	$14,295	289	$22,767	190	$20,341
Carbonate (crude)	5,340	327,400	3,299	207,417	5,032	295,066	4,523	240,451	4,300	291,341
Carbonate (refined)	5,572	395,728	5,313	383,958	7,018	412,587	5,211	368,858	1,165	92,959
Chloride	214,283	6,449,575	242,033	7,235,728	223,837	6,737,757	263,039	7,925,781	102,732	3,666,118
Chlorate	12	2,096	21	3,444	618	66,609	20	3,408	13	4,614
Chromate	11	1,699	22	2,273	14	2,601	17	2,822	20	3,317
Cyanide	1,163	326,973	1,048	312,777	475	137,535	618	183,259	370	141,331
Hydrate (crude)	3,713	309,965	4,211	330,684	4,497	348,500	4,283	336,650	.....	.....
Hydrate (refined)	41	9,254	39	8,096	56	11,919	9	1,977	.....	.....
Kainit	656,842	2,637,106	479,817	2,400,590	466,184	2,149,689	589,245	2,579,619	79,001	444,769
Nitrate (crude)	4,645	282,835	3,086	213,258	5,495	288,995	1,764	115,470	335	22,483
Nitrate (refined)	426	38,384	221	23,896	197	22,142	182	20,173	34	4,222
Prussiate (red)	27	10,230	35	11,264	33	1,103	45	15,325	41	14,922
Prussiate (yellow)	889	180,584	1,036	203,295	1,406	309,309	1,754	390,021	1,155	252,711
Sulphate	53,135	1,952,371	50,551	1,853,236	48,023	1,798,362	50,384	1,887,491	21,852	1,071,761

The Cottrell Process for Potash Recovery*

A Description of the Collection by Electrical Precipitation of the Volatile Vapors of Alkali Salts from Iron Blast Furnaces and Cement Kilns

BY LINN BRADLEY
Chief Engineer of the Research Corporation

THE subject of potash recovery is becoming of more universal interest to the public as well as to the technical man. The daily press and the magazines frequently refer to what is being done and to what should be done in this country in order to offset and decisively defeat the Kaiser and his followers. Recently several news items and editorials have appeared in the metropolitan press calling our attention to what is being accomplished in England toward making their country independent of Germany, and it appears that the British Government has furnished large sums of money to assist in recovering potash from their iron blast furnace gases. It is predicted that this source will enable England to obtain enough potash to equal her entire pre-war importation from Germany. France is reported to be as keenly awake to the possibilities along this line and we may see the time when France will be recovering large quantities of potash from iron ores which Germany has made such strenuous efforts to control. However, it is not surprising that interest in potash should increase, when we consider that this is the one big economic weapon which Germany has relied upon to regain her place in the sun after the war. She boasts that all countries will have to depend on her for potash. She claims that other countries can not produce potash to compete with that supplied by Germany. But in this as in many other instances her reasoning is based on lack of information as to facts and possibilities.

The recovery of potash in this country is making rapid strides. The industry may be roughly divided into those plants in which the recovered potash is the main product and those in which the potash is recovered as a by-product. In this paper the latter phase will be considered as it is believed that while the largest immediate tonnage may be obtained from desert lakes, kelp, alunite and a few other sources, nevertheless a study of the economic problems will show that the surest way of making our potash industry a permanent and enduring one, able to supply all of our requirements even against German competition, is to develop and rely upon the by-product potash.

FIRST CEMENT PLANT INSTALLATION

After the installation of the Cottrell processes at the plant of the Riverside Portland Cement Company in California was placed in operation for the purpose of eliminating the dust nuisance, it was noticed that the material collected in various parts of the precipitator differed in fineness. Natural inquisitiveness then called for an analysis of these products to determine if any impurities in the raw mix had become concentrated in any portion of the dust. The alkalies increased with the fineness of the material as shown by screen analyses. At that time considerable light fume was escaping from the precipitator exits and the suggestion was made and urged that some of this material be collected and analyzed as it might show even higher alkali content, since having been interested in agricultural and fertilizer problems it seemed to some of us that potash might be found in the escaping fume in percentages such as would warrant its recovery. Thus the first commercial potash recovering plant in this country was established. The engineer in charge of this work was Mr. W. A. Schmidt of Los Angeles. Since that time a number of improvements have been developed and the commercial success of the potash plant at Riverside has been the cause of several other cement plants installing potash recovery plants.

INVESTIGATION MADE ON BLAST FURNACE DUST

Early in 1912 the Research Corporation of New York started to develop the Cottrell processes and apply them to various plants in the eastern portion of the United States. Shortly after work had been begun, a paper was read and a demonstration given at a meeting of the local section of the American Chemical Society near Allentown, N. J. The next day arrangements were made for a visit to the South Bethlehem plant of the Bethlehem Steel Company. Having in mind the experiences of the Riverside cement plant, curiosity was aroused by the appearance of the gases coming from the tall brick stack connected to the boilers. An investigation was undertaken by Mr. R. J. Wysor and this resulted in extensive investigations thereafter to determine the possibility of cleaning these gases by the Cottrell processes and recovering whatever of value could be obtained from the collected material. Mr. Wysor has published a very able and valuable article in the *Transactions* of the American Institute of Mining Engineers (1917) giving a great deal of data on ores, fluxes, slags, potash balances and other items directly related to the recovery of potash as a by-product of blast furnaces. His paper probably served as an inspiration for much of the work which has been undertaken abroad.

Analyses of iron ores, cokes, limestones and dolomites show a wide variation in potash content, and it is therefore advisable for one interested to make sure that his raw materials are sufficiently rich to warrant a potash recovery plant. Furnaces which produce a large tonnage of slag per ton of iron on account of the iron content of the furnace charge will, of course, carry more potash into the slag than furnaces which produce

*A paper read at the Fourth National Exposition of Chemical Industries, New York City, September 25, 1918.

a relatively small volume of slag, other things being equal except for composition of the charge. Some iron ores carry as high as 60 per cent of iron and are practically devoid of potash. Some cokes have a low ash and are low in potash. Some limestones and some dolomites may be quite pure. If, therefore, the ores are uniform and properly prepared and the fuel and flux are properly proportioned, the slag volume will be small and the potash in the gases may likewise be negligible. On the other hand, if the iron ore carries as much as two or even one per cent of potash (K_2O) and the coke ratio is high and it and the flux contain as much as .25 to .50 per cent of potash, quite a large quantity of potash will be volatilized and carried off by the gases from which it can be recovered. The high temperature in the blast furnace and the length of time under treatment allows the silicates to be decomposed more readily than in a cement kiln where the temperatures are not so high. The potentialities of the by-product recovery from blast furnaces would, therefore, seem to surpass the possibilities of the Portland Cement Industry in this regard.

Numerous attempts have heretofore been made to recover potash from silicate rocks. The investment and operating cost, especially for fuel, are hard to overcome if one endeavors to volatilize the potash and recover it and nothing else. It therefore seems that the best way to recover the potash from these silicates by heat treatment is to charge these silicates into existing furnaces along with the regular charge and recover the potash as a by-product, thus eliminating the investment and operating cost for new and separate furnaces. This would be profitable up to a certain point, beyond which this practice would, however, not be desirable.

Since the investigations referred to were begun at South Bethlehem, numerous other furnaces have been investigated and potash balances made. Iron ores have been found in abundance in Alabama which carry from one to as high as three per cent in potash and carry enough iron to make them highly suitable for this purpose. The following tables show the results of one investigation.

PERCENTAGE ANALYSES OF MATERIALS

Material	Fe	SiO_2	Al_2O_3	CaO	MgO	Ash	Carbon	Na_2O	K_2O
Ore No. 1	46.36	17.42	4.19	5.03	8.33	.....	.....	0.62	1.27
Ore No. 2	54.69	12.78	3.49	4.04	6.00	.....	.....	0.39	0.74
Stone	.....	1.56	0.58	46.24	7.25	.....	.....	0.64	0.26
Coke	.....	5.82	3.49	0.51	0.24	13.01	86.15	0.39	0.32

CHARGED INTO BLAST FURNACE

Materials	Lb. per Ton Iron	Total Lb. K_2O	Per Cent. of Total
Ore No. 1	3,115	39.56	61.0
Ore No. 2	1,168	8.65	13.2
Stone	1,440	3.74	5.8
Coke	4,050	12.97	20.0
Total	9,773	64.92	100.0

SUMMARY

Total K_2O charged into furnace per ton of iron produced, lb.	64.92
Lost in slag per ton of iron produced, lb.	11.60
Lost as fume from gas leaks per ton of iron produced (estim.), lb.	1.16
Total potash recoverable from gases per ton of iron produced, lb.	52.16
Total potash in dust in gases as per analyses, per cent	34.11
Water soluble potash in dust in gases as per analyses, per cent	32.10
Portion of total potash in dust, which is water soluble, per cent	94.11
Total water soluble potash recoverable per ton of iron by collecting the dust in the flue gases, lb.	49.09
Total water soluble potash as above per 500 tons iron per day, lb.	24545.00
Total water soluble potash as above per year of 350 days, tons	4295.37
Portion of total potash charged into furnace which is recoverable from gases in water soluble condition, per cent	75.62
Safe estimate of above amount recoverable in operating practice, per cent	80.00
Safe estimate of above amount recoverable as above per year of 350 days, tons	3436.29

A study of the above figures will show that it is desirable to keep the potash content of the raw materials up to the highest point and to keep the slag volume and potash content as low as possible. It is clear that if the slag volume remained constant as well as its analysis that if only 11.6 pounds of potash had been contained in the furnace charge there would have been nothing available for collection. With suitable slag volume and potash content and a rich potash charge, the recovery of potash in quantities worth while is readily obtained. Sodium chloride has been found helpful in liberating the potash in such way that it is recoverable in the dust in a water soluble form. While working at a cupola furnace in which sash weights were made from old tin cans and other metal waste, it was found that the use of common salt, sodium chloride, greatly increased the fume volume and density and this later was shown to be due to the fact that chlorides of lead, tin and zinc were formed and readily volatilized as such. The use of salt has been extended to cement kiln practice and to other uses in connection with the recovery of silver, lead and zinc from low grade ores and tailings, the values being recovered from the gases after volatilization as chlorides.

Consideration of data such as presented in the tables given below resulted in an effort being made to find raw materials suitable for making iron and yet carrying high percentages of potash. Samples of ores, fluxes and cokes were obtained from a number of furnaces and other sources, and later on this work was carried on much more extensively by the Bureau of Soils of the Department of Agriculture. It is probable that Mr. Frederick Brown of that Bureau has now collected data on nearly all of the raw materials available for iron making and that if such data were made public in the near future, it would be of great assistance in connection with the problems under consideration. Personal efforts to find materials such as described developed the fact that in the eastern part of Alabama there is a very large tonnage of iron ores carrying in some cases an average of one per cent of potash and in other instances an average of about 1.80 per cent of K_2O, several analyses showing a content of over 3 per cent K_2O. I am indebted to Dr. J. S. Grasty for having brought these ores to my attention and for much of the data on their iron and potash content as given later in this paper. Mr. M. W. Bush, President Shelby Iron Company has also contributed data on the iron situation of the South and the values of these iron ores in furnace operations. I have examined these properties and have interviewed blast furnace operators who have used them in their furnaces and hold the opinion that they constitute an asset of importance to the nation as well as to interested parties. They should receive the consideration of the Government in connection with our war

problems and likewise our post-war problems so as to assist in rendering our country absolutely independent of Germany. The ores carry an average of from 48 to 52 per cent of iron, are very uniform, easily mined and shipped as they are directly on the railroad, and operate satisfactorily in the furnace producing good iron at low cost. Their potash content also acts as a desulphurizer, thus improving the grade of iron. The phosphorus content is very low.

The following table has been compiled to show the economic importance of these ores as a source of potash, the figures having been based on experience at several other furnaces as well as on the data obtained in connection with these particular ores and at various iron furnaces in the South. The tables has been submitted to experienced iron blast furnace operators for suggestions and criticisms. For comparison, other ores have been included in the table. The composition of the high-potash iron ore has been taken from the average of over one thousand tons of such ore shipped to furnaces on which K_2O was determined for each car of this particular shipment.

PERCENTAGE CONTENTS

	Coke	Stone	No. 1 Gray	No. 2 Red	No. 3 Brown
Silica SiO_2	8.70	2.00	19.2	15.0	19.5
Alumina Al_2O_3	5.00	1.00	4.8	4.0	3.8
Lime CaO	0.30	53.00	1.3	17.0	6.0
Potash K_2O	0.30	0.30	1.8	0.2	0.2
Iron Fe	1.70	0.00	49.8	36.0	42.0
Ore required for one ton iron, lb.			4398	6039	5212
Percentage of burden			46.07	54.35	46.87
Coke required for one ton iron, lb.			2700	3900	3000
Percentage of burden			28.29	35.22	26.98
Stone required for one ton iron, lb.			2448	1159	2909
Percentage of burden			25.64	10.43	25.15
Total potash content of burden per ton iron, lb.			99.5	29.57	33.97
Deduct for losses in slag and elsewhere			10.4	15.6	14.0
Total potash collectible from gases, lb.			89.1	13.97	19.97
Slag volume per ton iron, lb.			2715	3290	3090
Total potash in gases per day (500 tons iron)			44550	6985	9985
Total potash in gases per 350 day year, tons			7796	1222	1747
Assume eighty per cent recovery, this equals			6237	978	1406
Value per annum at $500 per ton of K_2O			$3118500	489000	703000
Value per annum at $100 per ton of K_2O			623700	97800	140600

The total production of pig iron in this country is such that about 200 furnaces of such size as referred to above would be required to meet our requirements if the furnaces were of the same capacity. So it is easy to see that we now have sufficient furnace capacity to produce annually over 1,500,000 tons of potash per annum, far in excess of our pre-war requirements. The difficulty lies in the fact that we have not found that all furnace burdens carry the amount of potash shown under the No. 1 column. If the furnace charges and operations could be adapted so that one-fifth of the amount, or 300,000 tons, could be produced this would meet our needs without assistance from any other source. The three constituents of the charge, ore, stone and coke, contain more or less potash. By using those raw materials which carry more than usual amounts of potash, our recoveries can be considerably augmented. In cases where ores are smelted which are excessively limey, feldspar, potash bearing slate or other potash bearing silicates could be fed into the furnace and thus increase the potash content of the furnace burden.

By-Product Potash From Feldspar Cement

Mr. H. E. Brown, a chemical engineer of New York City has developed a process for making a special cement from the slag obtained from a blast furnace and at the same time recovering water soluble potash from the gases. He charges limestone, coke and feldspar into the furnace. Now if iron ores of suitable kind could be used for a portion of the raw material, it might be possible to produce potash from the gases, also pig iron, and a slag which could be readily converted into a marketable cement. As the market varies with the supply and price, the furnace charge could be varied so as to increase the potash and reduce the iron or vice versa. The process has been developed to the extent that both potash and the special cement can be produced but investigations looking to a reduction in the operating cost have not been completed. It appears, however, that with an assured market for the cement at fair prices, the process can be operated successfully and show a good return on the investment, especially when the price for potash is high. In this connection, it seems that consideration might well be given to the use of powdered coal introduced through the tuyeres and thus reduce the coke required and possibly doing away with it all together. It would materially reduce operating costs and increase production and recoveries.

Potash From the Georgia Cambrian Slates

It is natural to look to feldspar and other potash bearing silicates for our potash. The cost of mining and grinding feldspar is one obstacle to be overcome which is not an obstacle for instance in the Cambrian slates of Georgia. It has been suggested also that efforts be made to recover potash from the tailings dumps in the Cripple Creek District of Colorado, these tailings carrying as high as 7 per cent of K_2O. Investigations as to the feasibility of this are now under way. Sufficient progress has not yet been made, however, to warrant any very optimistic statements. The fuel cost and the necessity for a long freight haul to the fertilizer consuming districts are large items to overcome.

Serecites and Cambrian potash bearing slates have been located in Georgia which carry potash in considerable quantity, several deposits analyzing as high as 8 per cent or 9 per cent. Laboratory investigations have shown that the potash in these raw materials was more readily rendered water soluble or volatilized by treatment with salt in a rotary kiln than the potash from feldspar. Furthermore, the amount of lime required to be added to the charge before the potash is liberated appears to be much less than required for feldspar. The cost of production is much less than in the case of feldspar and the cost of grinding is very much less and altogether these slates are much better adapted for the purpose here discussed than feldspar is. Dr. T. P. Maynard of Atlanta, Georgia, who conducted these researches and developed the properties, reports that there is an enormous tonnage available. It is also reported that a company has been treating this material in a rotary kiln, adding 200 to 300 pounds

of salt per ton of raw material, volatilizing a good portion of the potash and converting a large percentage of the balance into a water soluble compound in the clinker. Freight rates should be very low since this material is located very close to a large market, namely the cotton fields of Georgia and Alabama. Engineers state that cotton grows prolifically on these lands without any additional fertilizer, indicating the ease with which the potash is made available.

Cottrell Process Installations In Cement Plants

In all of the cases mentioned above, potash is volatilized and must be recovered from the gases. The Cottrell process has met with excellent success in this phase of potash recovery problems. The field of application which has been developed the farthest is in the recovery of potash from cement kiln gases. Several plants are now in successful operation and at the present time a considerable tonnage is being obtained in this manner. Other plants are under construction and the outlook for a much larger tonnage is very favorable. In the August 21 issue (1918) of *The American Fertilizer*, published at Philadelphia, Penn., John J. Porter, General Manager of the Security Cement and Lime Company of Hagerstown, Maryland, in an article entitled "The Recovery of Potash as a By-Product in the Manufacture of Portland Cement," gives a great deal of valuable information upon this problem. The following is quoted from that article. "Estimating Potash Recovery." For the benefit of those who may wish to figure on their own conditions, I give the following method of calculating the probable recovery of potash:

Let A equal per cent potash in raw mix.
B equal per cent potash in clinker.
C equal per cent liberation = 600A — 380B ÷ 600A.
F equal lbs. of potash recombined per bbl. clinker = 0.7 to 1.5,
depending on fuel consumption and per cent ash in coal.
Let P equal per cent potash precipitated in treaters.
Assume 600 lb. of raw mix actually used to make 1 bbl. of clinker,

then—Lb. of potash entering kilns per barrel of clinker equals 600A.
Lb. of potash volatilized in kilns per barrel clinker equals 600 AC.
Lb. of water soluble potash entering treaters per barrel clinker equals 600 AC-F.
Lbs. of water soluble potash collected in treaters per barrel clinker equals (600AC-F) X P.

* * *

The cost of collecting potash at Security is now running about as follows:

	Per Unit of Potash
Collection, including labor, power, repairs and laboratory	$0.14
Packing and shipping	0.08
Total operating cost exclusive of depreciation, royalty and salt addition	$0.22

The cost of the salt addition is about $0.25 per unit of potash, but this is not a necessary element of cost and can be omitted whenever price conditions become such as to give an unsatisfactory margin of profits.

The article then goes on to show that from a 3000 barrel cement plant, the operating profit per annum on the potash alone comes to about $458,000, the raw mix having 0.75 per cent of potash. The article is quite complete and those interested are referred to it for further details. The Bureau of Soils published the results of their survey of cement plants. The data given indicates that this industry can be counted on to furnish 80,000 to 100,000 tons of potash annually. By using materials which are higher in potash content, such as feldspar, serecite or slate in part, the yield of potash can be materially increased. The additional cost for raw material should be weighed against the greater financial return from the plant operation as a whole and not allow first cost per ton of material to govern. The utilization of existing cement kilns and equipment for the manufacture of cement as a by-product, placing special emphasis on the potash yield and profits therefrom, should be urged by all citizens, and this should be more emphatically urged for the recovery of potash from blast furnace gases. The feat of obtaining all of our potash from existing industries by recovering the by-products will be typically American and worthy of our "Yankee ingenuity." The by-product method will enable us to compete with potash from any other source, and the Kaiser's vain boasts that all countries will be compelled to submit to his will because they must have his potash, shall receive their proper answer.

Potash Prospects In the Iron Industry

Referring again to the iron industry and its relation to the potash question, it should be pointed out that in the Alabama district there is an abundance of excellent coal, labor is plentiful and cheap, and the climatic conditions are such that the district may be considered an all year one as far as operating is concerned. Then, when it is realized that there is immediately at hand an enormous tonnage of high grade iron ore which carries such a large potash content and that the South produces our cotton and therefore is the large consumer of potash and thus provides a large market within a few miles, the economic importance of this situation can be better appreciated. Other iron ores contain potash, some of which may justify recovery plants, and we should be on the lookout for such materials, keeping in mind that our goal is to obtain our potash as a by-product at such a cost as will enable us to ignore Germany forever and thus make the dreams of the American chemist and engineer come true.

The South produces pig iron cheaper than any other district in normal times. In fact their furnaces must do this in order to stay in the market. The South does not yet consume as much iron and steel products as its population justifies and therefore their iron must carry a high freight charge if it is shipped North to the larger markets. The manufacture of cast iron pipe has, however, grown to a large industry. In the future more and more iron and steel will be consumed locally as it is evident that the South is coming into its own very rapidly. The additional profit which can be obtained from the potash will be of great assistance in keeping their iron furnaces in blast when the market sags. The South has a very fortunate combination of labor, raw materials, climate and a large and near fertilizer market. In France and in Great Britain the Governments have taken an active interest in the possibilities along the lines herein pointed out. It has been reported that investigations extending over a period of three years have shown that Great Britain can produce enough potash to satisfy all her requirements.

63 Wall Street,
New York City.

Potash from Alunite in Utah

By John W. Hornsey

THE arbitrary action taken by the German Government some years ago in forcing Americans who had purchased interests in German potash works to join the German Potash Syndicate and the lack of tact displayed by those who handled the situation for Germany, created so much ill feeling that all together it brought about the determination upon the part of the United States Government and of American buyers to find some source of potash other than the German, and plans were thereupon made for both governmental and independent searches. Fortunately for this country, when war was declared in 1914 these searches had developed a large amount of valuable data.

Both the Geological Survey and the Bureau of Soils were granted appropriations and began active work, which has proved to be of considerable value. However, the independent investigators made a somewhat more comprehensive survey without going quite so exhaustively into details, except where it seemed reasonably certain that a commercially workable supply would be found.

All probable sources of supply were investigated, including feldspar, kelp, desert lakes, leucite and alunite. It was evident from the start that potash could not be produced profitably at anti-war prices from certain of these materials without the production and sale of by-products, and for some of these by-products there was only a limited market. In other cases a somewhat more careful study of the subject showed that potash was unquestionably the by-product. This work has, however, definitely resulted in the development of a permanent potash industry in this country, and I say permanent advisedly, for some of the plants will, undoubtedly, be able to continue after the war.

Alunite

Many centuries ago alunite was mined in Smyrna and for about 400 years in Italy and was used for the production of potash alum. When the search for potash began in this country, it was felt that a deposit of alunite might be found and that it might be used as a source of potash rather than potash alum. About this time such a deposit was discovered in southern Utah, a few miles from Marysvale. Later it seemed that it would be necessary to discover some means of refining the alumina before potash could be produced in competition with Germany. However, early in 1915 when the price of potash had risen to what seemed impossible figures, Mr. Howard F. Chappell and his associates of the Mineral Products Corporation decided to build a plant, and this has been in continuous and successful operation for three years, except for two shutdowns of one or two months each caused by fires. They are now producing and shipping about 600 tons of sulphate per month, and the product is considerably better than 90 per cent pure.

Several formulas are given by various authorities to indicate the chemical composition of alunite a double sulphate of potassium and aluminium, of which the following is representative:

$$K_2O:3Al_2O_3:4SO_3:6H_2O$$

The above formula appears to be nearly correct, i.e., for the alunite now being worked at the town of Alunite near Marysvale. Several methods have been proposed for the treatment of an ore of this character for the production of potash, but probably the simplest one is that employed in this plant where the ore is calcined at approximately 1000 deg. C. This drives off water of crystallization and sulphuric acid, leaving water soluble potassium sulphate and alumina. Upon leaching and evaporation of the resulting solution, potash is recovered as sulphate with a very small percentage of soda and some infinitely fine alumina which has passed through the filter cloths.

The alunite from the Mineral Products Corporation's mine is of a distinctly crystalline nature and from 96 to 97 per cent pure alunite. There are other large deposits nearby but they are more nearly amorphous in appearance and carry more silica, which seems to interfere with the calcination and also with the subsequent refining of the alumina.

The alumina residue, containing any silica present in the ore, is now discarded; but it is planned later to refine and use it. It has been discovered that the silica content may be reduced to less than one-half of one per cent by calcination with producer gas instead of pulverized coal and separation of the alumina from the silica by flotation. The average silica content of the ore used by Mr. Chappell's company is 3½ per cent. The loss on ignition is approximately 40 per cent, and the raw ore contains an average of approximately 10 per cent of K_2O, or 18½ per cent of K_2SO_4. The plant is operated profitably, and by reason of improvements and refinements which have gradually been developed, will, it is believed, be able to compete with Germany after the war.

Pintados Deposit in Chili

About sixty miles from the coast and directly on the railroad in northern Chili, is a deposit which while it cannot be correctly called a lake the result is essentially the same, and contains several hundred thousands of tons of workable potash in the form of a crystal body directly on the surface, averaging about 18 in. deep and covering many thousands of acres. The average analysis will show about 5 per cent of K_2O. This potash upon leaching and crystallization can be recovered as the muriate, or, if mixed with the raw material from which sodium nitrate is made and which immediately joins this deposit, can be recovered as the nitrate.

While this deposit is not in the United States, it is 1000 miles nearer to New York by water than California and is located where labor and other conditions are so favorable as to offset the high price of fuel. The climate is better than at some points in our western deserts and the country has a stable government. Revolutions are unknown and there has been less change in their constitution and general governmental methods during the past century than in the United States, England, France, or any other large country.

Great Salt Lake

This is a body of brine that has not gone nearly so far in the process of desiccation as Searles Lake. It has, however, for some time been looked upon as a possible source of potash. In fact, the Diamond Match Co. has had a plant in operation there for the past two or

three years, and has recently doubled its output. The Virginia Caroline Chemical Company in coöperation with the Inland Crystal Salt Company of Salt Lake City has also built a plant. However, the composition of the brine of the Lake is such that a very large amount of evaporation is necessary before the bitter liquors are sufficiently saturated with potash to make them workable. The primary evaporation is effected in open air, clay-lined ponds, during which considerable quantities of sodium chloride are thrown out. The bitter liquor remaining is then worked up for the separation of potash which is effected by evaporation, heating and cooling; and depends upon the varying relative solubilities of the different salts. The principle difficulty encountered is to bring about a satisfactory separation of magnesium chloride.

Potash from Iron Ores and Fluxes

To the Editor of Chemical & Metallurgical Engineering

SIR:—Your editorial in regard to the recovery of by-product potash from blast furnaces is very timely. Only a few days ago I heard an expert connected with the War Industries Board express the view that the infant potash industry of this country may prove to be of an importance far above that represented by our immediate needs for potash, in connection with the negotiations for peace. The idea is that Germany will probably attempt to use her supposed monopoly of potash as a club to secure better terms, and certainly many utterances of her public men can be cited to bear out this theory. As it happens, there is in the August 1 number of the *Journal of Industrial & Engineering Chemistry*, page 665, a translation of an article from the *Deutsche Wirtschafts-Zeitung* of January 15, 1918, on "The German Potash Industry" in which the same idea is clearly expressed. In view of this probability, an established potash industry in this country might easily have a value not to be reckoned in dollars and cents if used to call the German bluff.

The recovery of potash in connection with the manufacture of Portland cement is going ahead very rapidly and largely because of the successful experience of the Security Cement & Lime Company. There are at the present time fourteen potash-recovery plants either in operation or in course of construction. Of these, eight are using or will use the Cottrell system, while six will use various other systems of collection.

The industry is still in its infancy and great advances in technical efficiency are possible. At Security we have already succeeded in increasing our percentage of potash volatilized (and thereby made available for collection) from about 40 to about 75 per cent. It is undoubtedly possible to carry this liberation even higher and it is also possible to greatly increase the efficiency of the collection apparatus. Even on the basis of the present state of the art, however, the cement industry is capable of furnishing approximately 100,000 tons of K_2O per annum or about one-third of the total requirements of the country.

Data do not exist for the calculation of the possibilities of the iron industry as a source of potash, but as you have pointed out, they are probably very great, and in some respects the proposition is more attractive than in the case of the cement industry. In the blast furnace the volume of gases to be treated is much less per ton of material passing through the furnace than in the case of the cement kiln so that on the basis of equal potash content, the size of the investment in collecting apparatus would be less.

As I was at one time connected with the blast-furnace industry, I have been much interested in the possibilities of potash collection there ever since the success of our cement installation had been demonstrated. In coöperation with Mr. O. M. Stull of Buena Vista, Virginia, I have worked out a potash balance for one blast furnace and, so far as I know, these are the first data of the sort to be presented, with the exception of Wysor's excellent work published in the 1917 *Transactions* of the A. I. M. E.

	Tons	Lb.	Per cent		K_2O, Lb.	Per cent of Total
Coke	2,500	× 2,000	× 0.384 ÷ 100	=	10,333	39.3
Pyrites Cinder Nodules	744.9	× 2,240	× 0.504 ÷ 100	=	8,409	17.0
Manganese ore	159.1	× 2,240	× 0.895 ÷ 100	=	8,192	16.4
Brown ore	1,581.7	× 2,240	× 0.227 ÷ 100	=	8,062	16.4
Total ore	2,485.7					
Dolomite	741.1	× 2,240	× 0.268 ÷ 100	=	4,449*	9.0
Limestone	741.1	× 2,240	× 0.350 ÷ 100	=	5,810*	11.8
					49,282	100.0
Pig iron*	1,360	× 2,240	× 0.045 ÷ 100	=	1,371	2.8
Slag	1,444	× 2,240	× 0.500 ÷ 100	=	16,172	32.9
					17,543	35.7
Volatilized					31,639	64.3

*The percentage of potash found in the pig iron is so small as to raise the question whether it is not due to analytical error. However, the net result as to potash liberation is, in any event, only slightly affected.

This balance is based on a two-weeks' run, all materials except the slag being weighed and all analyses made in duplicate by a chemist experienced in potash determination. The weight of the slag was calculated. It will be noted that the percentage of potash volatilized from the furnace and which might, therefore, be recovered was 64.3 per cent of that entering the furnace, and amounted to 31,639 lb. in the two-weeks' period. As this furnace was working on a lean mixture with large slag volume and a fairly siliceous slag, it is probable that this figure represents somewhat less than the average liberation to be expected in blast-furnace practice.

These analyses show that the brown ores of Virginia are relatively low in potash; some published analyses in old reports of the U. S. Geological Survey show that this is also true of the majority of the Lake Superior ores. The Clinton red ores of the South are also low in potash.

The grey hematites of Eastern Alabama are probably the principal deposits of high-potash iron ores available in this country. The quantity of these ores has been estimated at 50,000,000 tons and upwards and the potash content ranges all the way from 1 to 3 per cent and over. It will probably average about 1.5 per cent. A little calculation will show that the possibilities for potash production from these ores are very attractive indeed. Aside from potash content, the analysis of the ore is very similar to the average brown ore of Alabama, and it has been used successfully at various times in blast furnaces in this district. An attempt is now being made to work out a project for the use of these ores involving the recovery of their potash content and it is to be hoped that it will meet with the success which it deserves.

JOHN J. PORTER.

Security Cement & Lime Co.,
Hagerstown, Md.